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AN ECONOMIC ANALYSIS OF KENYA'S SUGAR INDUSTRY WITH SPECIAL REFERENCE TO THE SELF-SUFFICIENCY PRODUCTION POLICY

by

© STEPHEN GICHOVI MBOGOH

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF DOCTOR OF PHILOSOPHY

IN

AGRICULTURAL ECONOMICS

DEPARTMENT OF RURAL ECONOMY

EDMONTON, ALBERTA

FALL 1980

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled AN ECONOMIC ANALYSIS OF KENYA'S SUGAR INDUSTRY WITH SPECIAL REFERENCE TO THE SELF-SUFFICIENCY PRODUCTION POLICY submitted by STEPHEN GICHOVI MBOGOH in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Agricultural Economics.

Supervisor

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ABSTRACT

The objectives of the study included: (i) determination of demand and supply functions for sugar and assessment of the structure and general behaviour of the sugar industry; (ii) evaluation of the performance of the sugar industry in relation to the self-sufficiency policy; (iii) prediction of future developments of the sugar industry in relation to the self-sufficiency policy; and (iv) formulation of market improvement proposals that could find useful applications in the sugar industry. These objectives are stated in relation to Kenya's sugar industry.

Relevant data were obtained and analysed using relevant analytic models and statistical procedures. The hypotheses based on the stated objectives were then tested. The results of these hypothesis tests in relation to Kenya's sugar industry were:

(i) Changes in cane and sugar prices have a significant impact on cane and sugar production;

(ii) Increases in the prices of competitive products, especially with regard to maize prices, have an adverse effect on cane and sugar production;

(iii) Changes in the level of sugar price and national disposable income have a significant impact on sugar consumption;

(iv) Domestic price of sugar is positively correlated to the world market price of sugar;

(v) The lag in adjusting cane and sugar production to desired levels following changes in cane and sugar prices is statistically significant;

(vi) The Government policy has not been effective in relation to achieving the self-sufficiency goal within the 1966-1976 target period;

(vii) Kenya is likely to become self-sufficient in sugar during the next decade.

The performance of the sugar industry is thus found to be unsatisfactory from the self-sufficiency norm, although the performance is considered to be satisfactory from the (i) stability of prices, employment and output, and (ii) labour relations criteria. An important conclusion of the study is the fact that both production and consumption of sugar are sensitive to economic factors. Price and income elasticities are found to be low, although the results are comparable to those obtained from studies on sugar industries in other parts of the world. Therefore, the use of a sugar pricing policy to influence production and consumption in order to achieve a self-sufficiency status would likely lead to a high consumer price and take a relatively long time to achieve its objectives. Such a policy is considered socially inequitable.

This study recommends an alternative sugar policy that is likely to lead to self-sufficiency while maintaining a sugar price that is considered more socially equitable. The recommendations involve (i) the indexation of the current domestic sugar price to the fluctuations in the world market price of sugar, and (ii) the operation of a price-support fund from which the Government is to subsidize domestic sugar production only when the average production cost exceeds the indexed domestic sugar price. These recommendations are considered equitable in the sense that they do not disrupt the established production pattern, yet they result in a fair price to consumers because there is no longer a need to increase the sugar price just for the sake of giving a price incentive to producers.

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I am grateful to my supervisory committee members, who included Dr. Murray H. Hawkins as the chairman and Drs. L. Bauer, W.E. Phillips and B. Von Hohenbalken as members. Dr. J.J. Richter served as a member of this committee during the early stages of my program but had to leave when he took his sabbatical leave. To all of the committee members, your guidance, patience and criticisms were the inspiration that enabled me to execute the study that is presented in this thesis. I am, however, fully responsible for any errors or omissions that may still occur in the thesis.

A special vote of thanks goes to the Canadian Commonwealth Scholarship and Fellowship Committee which provided me with the scholarship in Canada and to the University of Nairobi, my employer, which granted a study leave and supported me in various ways. I am proud of the staff and fellow students in the Department of Rural Economy, University

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CHAPTER I

THE PROBLEM AND ITS SETTING

The Evolution of the Study

The Government of Kenya[1] currently pursues a policy of self-sufficiency in food production. The long-term objective of such a policy is to develop the country's resources in order to produce all its food requirements, with an exportable surplus if possible. Such an objective has been the guiding principle in the development and promotion of sugar production in Kenya since the Government declared sugar production a "scheduled crop"[2] following the attainment of Kenya's political independence in 1963. However, the Government's target of achieving self-sufficiency in sugar production has not been realized despite earlier plans to achieve the goal by the 1970s.[3]

Background to Kenya's Sugar Industry

Kenya produces cane sugar, the bulk of which is consumed in the semi-refined form known as mill-white sugar, which is yellow-white in colour and is suitable for most household purposes other than specialty baking. Industrial users of sugar generally require a more refined sugar for the making of beer, soft drinks and confectionaries, and for other forms of food and non-food sugar uses.[1]

---

[1] Hereafter referred to as the Government: the first letter of the term "government" will be capitalized in all cases where it is used to refer to the Government of Kenya.

[2] A "scheduled crop" in Kenya refers to any agricultural commodity whose production is regulated by a government policy, for instance through a marketing or a pricing policy.

[3] See Government of Kenya, Development Plan, 1974/78 (Nairobi: Government Printer, 1974).

The history of sugar production in Kenya dates back to the 1920s when the first sugar mill was established at Miwani, Nyanza Province, by a private company in 1924, followed by the establishment of the second mill at Ramisi, Coast Province, in 1927, again by a private company.[2] Each mill was established in a cane-production zone and was to depend on its own cane plantation, the so-called nucleus estate,[3] for cane supplies. The colonial government that ruled Kenya prior to the country's political independence in 1963 did not promote agriculture by Africans on a large scale. Only the two sugar mills, each depending on its own cane supplies, continued to produce sugar in the country prior to 1966, despite the fast growing market for sugar that had continued to develop in Kenya since the early 1920s.[4] Cane and sugar production became major enterprises in 1966 when the Government declared sugar production a scheduled crop and embarked on a number of sugar production and expansion projects. The sugar industry has continued to grow steadily since then.

The third sugar mill in Kenya was established at Muhoroni, Nyanza Province, in 1966 (by East African Sugar Industries Ltd.), followed by the fourth one at Chemilil, Nyanza Province, in 1968. The Mumias sugar mill, at Mumias in the Western Province, which became operational in 1973, was the fifth mill to be established in the country. There are plans to establish more sugar mills in the major cane-producing zones in order to process more sugar and be able to cope with the fast growing demand for sugar in Kenya.[1] However, the establishment of more sugar mills on its own cannot overcome the problem unless strong measures are taken to promote cane production and ensure that cane supplies to the mills are maintained steadily in order to keep the mills operating at close to their rated capacities throughout the year. Seasonality of cane deliveries to the sugar mills is one of the major causes of the widespread problem of underutilization of the mill capacities.[2]

---

[1] Ministry of Agriculture, Economic Review of Agriculture, Vol. 7, No. 1, January-March, 1975 (Nairobi: Government Printer, 1975).

[2] Confidential Report, Ministry of Agriculture, Nairobi, Kenya, 1976.

[3] A nucleus estate is a cane plantation that is controlled or owned by an individual sugar mill as a company. Private cane producers who supply a given mill with cane are known as outgrowers.

[4] See O'Connor, An Economic Geography of East Africa (London: G. Bell and Sons Ltd., 1971), p. 68.

Two of the sugar mills in Kenya, that is Ramisi and Miwani mills, are owned wholly by private companies. Muhoroni mill is owned by a private company, but the Government has some shareholding. The Chemilil and Mumias mills are owned wholly by the Government. Private firms manage their mills while the Government hires professional managing agents to run its mills on a contract basis. However, the Government has the overall control of the Kenya's sugar industry through (i) its regulation of the domestic prices of both the cane and the sugar; (ii) its control of both the domestic and the foreign trade in sugar; and (iii) its responsibility in designing and implementing cane and sugar production programs.

---

[1] At the time of writing this thesis (1979/80), the sugar mills being constructed at Awendo in South Nyanza and Nzoia in the Western Province, are about to become fully operational and this will substantially raise the level of domestic production of sugar.

[2] Ministry of Agriculture, Economic Review of Agriculture, Vol. 7, No. 1, January-March, 1975 (Nairobi: Government Printer, 1975).

The sugar mills have technical staff to manage and supervise the production of cane in their nucleus estates. The provision of extension services to the outgrowers (i.e., advice to farmers on cane production), is undertaken by the field officers of the Ministry of Agriculture and, in some areas, by the officers of either the Ministry of Lands and Settlement or the Ministry of Co-operative Development. In all cases, these technical officers endeavour to promote cane production in order to raise the level of sugar production in the country. In 1972 the Government established the Kenya Sugar Authority and entrusted it with the responsibility of promoting and fostering the development of cane and sugar production in the country. However, the Authority has so far been functioning in an advisory role to the Ministry of Agriculture and has been involved mainly in appraising schemes for the development and extension of cane and sugar production, in addition to the reporting of cane and sugar statistics to the Ministry of Agriculture.

The Government Sugar Policy

In the pursuit of a self-sufficiency sugar production policy, the Government has taken various measures in order to stimulate both cane and sugar production in Kenya. The pricing of both the cane and the sugar has been the major policy instrument employed by the Government in an endeavour to attain the self-sufficiency goal in sugar production at the earliest time possible. Other measures have involved the encouragement of private investment in the sugar industry, often including direct state participation in such investment projects, and the provision of technical advice to cane producers on how best to produce cane for sugar processing. A mix of all these measures has been expected to stimulate sugar production in the country.[1]

Progress toward self-sufficiency has been relatively slow in the case of sugar, when examined against the background of the current levels of production of the major foods or food products in Kenya, because consumption has been increasing faster than anticipated, while production has been lagging below the target since 1963.[2] The country has continued to import sugar in order to meet its domestic sugar requirements. However, the proportion of sugar imports to the total sugar consumption in Kenya has dropped from well over 65 percent prior to 1963 to about 25 percent (1977 estimate).

One of the Government's main objectives for a policy of self-sufficiency is to reduce imports and save foreign exchange. However, the Government is also concerned about the consumer welfare. An increase in cane price in order to stimulate sugar production has usually necessitated an increase in the price of sugar in order to cover the production cost. Such increases in sugar price could adversely affect sugar consumption, depending on the nature of sugar demand function. Hence self-sufficiency could be achieved at the expense of consumer welfare, which is undesirable, and a balanced sugar pricing policy would appear to be warranted.

The price uncertainty that has characterized the world market for sugar is also cited as a reason for promoting a self-sufficiency sugar production policy in Kenya. For instance, the relatively high level of the world market sugar price during the early 1970s is said to have reinforced the desire by the Government for a self-sufficiency sugar policy in Kenya. This desire led to the allocation of large sums of money to the development of the sugar industry in Kenya: out of the total planned agricultural development expenditure during the 1974/78 Plan period, 5.8 percent was to be spent on sugar development. This percentage represents a substantial expenditure on the development of a single agricultural commodity.[1]

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[1] See Government of Kenya, Development Plan, 1974/78 (Nairobi: Government Printer, 1974).

[2] Ibid, pp. 239-241.

The Need for and the Usefulness of the Study

As the section on the review of literature will show, little information is published about the structure, conduct and performance of the sugar industry in Kenya. There is an informational gap on the nature of supply and demand functions. Although a pricing policy has been used as the main instrument by the Government in its efforts to make Kenya self-sufficient in sugar, not much is established about how responsive the production, supply and consumption of sugar in Kenya are to price changes. Sugar production and expansion programs have so far been planned on the basis of the estimates of sugar supply and demand elasticities made by the Food and Agriculture Organization (FAO), which are becoming outdated.[2]

This study purports, inter alia, to close the informational gap on the sugar industry in Kenya.[3] Hence the major usefulness of the study lies in (i) the improvement of the knowledge about the structure, conduct and performance of the sugar industry in Kenya, especially with regard to the nature of supply and demand functions for sugar in Kenya; (ii) the analysis of the effectiveness of the Government policy on the performance of the sugar industry in Kenya; (iii) the establishment of the time period when Kenya might become self-sufficient in sugar, through the projections technique; and (iv) the development of a market model that could find a useful application in the improvement of the sugar industry in Kenya.

---

[1] Government of Kenya, Development Plan, 1974/78 (Nairobi: Government Printer, 1974).

[2] FAO, Agricultural Commodity Studies and Projections (FAO, Rome: Various Issues).

[3] The study is an integral part of the studies now being undertaken by the Department of Agricultural Economics, University of Nairobi, to generate information principally for teaching purposes.

Objectives of the Study

The Statement of the Problem

The primary objectives of this study are (a) to determine the nature of demand and supply functions for sugar in Kenya, and (b) to evaluate performance of the sugar industry in relation to the self-sufficiency goal under the current Government policy on sugar in Kenya. Projections of sugar production and consumption in Kenya over the next one decade are then done in order to ascertain the period when the country is likely to attain the self-sufficiency status. The cane producer's responsiveness to price changes is expected to directly influence the amount of sugar that can be produced. Hence an evaluation of the degree of responsiveness of cane production to price changes is considered a useful step toward closing the information gap. A secondary objective of the study is to develop a market model which could be useful when designing an improvement program for the sugar industry in Kenya.

Specific Aspects of the Problem

The following is a breakdown of the main aspects of the problem that are examined relative to the sugar industry in Kenya:

1. Determination of the degree of responsiveness of cane production and sugar supply to cane and sugar price changes;

2. Evaluation of the impact of the prices of alternative crops on the production and supply of sugar;

3. Determination of the coefficient of adjustment of cane production and sugar supply to cane and sugar price changes;

4. Determination of the degree of responsiveness of consumption of sugar to sugar price changes;

5. Determination of the degree of responsiveness of sugar consumption to income changes;

6. Determination of the impact of the world market sugar price on the Kenya sugar price;

7. Evaluation of the effectiveness of the Government sugar policy on the performance of the sugar industry; and

8. Projections of the quantities of sugar produced and consumed in Kenya over the next two decades and an assessment of the implications of these projections relative to the self-sufficiency production policy.

Hypotheses

Some minor hypotheses might be developed in the process of the analysis, and the following are the major hypotheses that are examined relative to the sugar industry in Kenya:

1. Cane production and sugar supply are responsive to changes in cane and sugar prices;

2. Sugar production is adversely affected by maize production, the main alternative enterprise in the cane-production zones of Kenya;

3. There is a lag in adjusting the level of cane production and sugar supply to the desired levels following a change in the cane and

sugar prices;

4. The demand for sugar is responsive to changes in sugar price;

5. The demand for sugar is responsive to changes in disposable income;

6. The Kenya sugar price is correlated to the world market sugar price;

7. The Government sugar policy has been effective; and

8. The sugar industry in Kenya can be expected to achieve the self-sufficiency status by the end of the 1980s.

The Organization and the Scope of the Study

The study is based mainly on the analysis of the time series data on production, consumption and prices of sugar in Kenya. The period covered is from 1955 to 1976. This period is chosen for two major reasons: (i) data availability; and (ii) possibility of comparing the performance of the sugar industry about a decade prior to and after Kenya's political independence which was attained in 1963. Production, consumption and price data for sugar and competing enterprises for the period covered are documented and the records can be considered to be accurate and reliable. There is little recorded information about the small-scale agriculture which was being carried out by the African population in Kenya prior to 1955. The colonial government in Kenya initiated the first program to promote general agriculture on a nation-wide basis, under the so-called Swynnerton Plan, after 1954.[1]

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[1] See, for example, Heyer, J., et al., Agricultural Development in Kenya: An Economic Assessment (Oxford University Press, Nairobi, 1976), pp. 125-147.

The basic assumptions of the analytic models in any study impose certain restrictions that generally reflect the scope of the study. Hence one should consider such restrictions in the evaluation of the analytic results. The utility-maximization assumption plays a major role in the choice of models for demand analysis. This assumption will be reviewed in the chapter on economic theory. The profit-maximization assumption plays a major role in the choice of models for supply response analysis. Therefore, a comparison of the relative profitabilities of the alternative enterprises that can be carried out in the cane-production zones of Kenya is considered a useful step toward determining the likely pattern of production if the producers were motivated by the desire to maximize profits. The information generated can also aid in the choice of the alternative enterprises that could be considered as competitive to cane and sugar production.

This study is not concerned with the comparison of the sugar production costs in Kenya with those obtained in other sugar producing countries and is basically limited to the determination of the supply and demand functions for sugar in Kenya and the evaluation of the performance of the industry during the last two decades. However, some projections are done in order to determine the future trends in sugar production, consumption and imports. The results of such projections are expected to have some important policy implications. A review of the world sugar market is also done in order to depict the uncertainty that has continued to characterize this market and which has led many nations to promote their domestic sugar production toward a self-sufficiency goal. The study gives some special reference to the self-sufficiency food production policy in Kenya, but does not attempt to evaluate the economic or social desirability of such a policy. Such an evaluation would likely involve additional value judgments. Therefore, the self-sufficiency policy is taken as a given goal that the country aspires to attain.

The thesis is organized under six chapters followed by a list of selected references and appendices. The first chapter introduces the problem and gives a statement of the need for, the usefulness and the scope of the study. The second chapter gives a review of the world sugar economy, emphasizing those aspects that affect the international trade in sugar. A brief overview of the relevant economic literature on the world sugar market is then presented. The third chapter discusses the sugar industry in Kenya, but a synoptic view of the role of agriculture and the agricultural development policy in Kenya is first presented before a presentation on the trends in domestic production, consumption and prices of sugar is offered. A review of relevant literature on the sugar industry in Kenya is then presented. The fourth chapter gives a review of the economic theory and the methods of analysis that are considered useful in the understanding of the study. The fifth chapter presents an appraisal of the data that were used in the study followed by a discussion of the evaluations and applications of the analytic results. The evaluations include the testing of the hypotheses. The sixth chapter presents a summary, conclusions and recommendations of the study.

CHAPTER II

A REVIEW OF THE WORLD SUGAR ECONOMY

Introduction

The sugar industry has evolved since the late 19th century, and has had a rapid growth in both the production and consumption since then. The rapid expansion of the industry in recent times can be demonstrated by the fact that the volume of sugar production and consumption doubled during the period between 1950 and 1965, and is expected to triple by 1980.[1]

In recent times, sugar has become one of the major agricultural exports of developing countries. In the 1960s, sugar as an export of developing countries was surpassed in value only by coffee and natural rubber. Hence sugar is an important source of income and foreign exchange earnings for many of the developing countries, and any improvements in the international sugar trade situation are of great interest to the developing countries. The recent moves by many nations to develop their own sugar industries and produce toward self-sufficiency, regardless of the cost of production, is seen as a great threat to the future of the international trade in sugar. Such moves toward greater self-sufficiency by many nations can be expected to adversely affect the incomes of the major sugar exporters, who are members of the developing countries.

The tendency by many nations toward greater self-sufficiency in sugar during the last two decades can be illustrated by the fact that while the world sugar production and consumption during the 1950-1970 period rose by annual averages of 5.6 percent and 5.8 percent respectively, the world net exports of sugar grew by an average rate of 3.1 percent per annum.[1] The overall ratio of production to consumption is found to have increased primarily in those countries that were initially both producers and importers of sugar. The steady decline in the ratio of world net exports to production ~~for~~ sugar is further demonstrated by the fact that the ratio was 31.4 percent during the 1951-1955 period, but had declined to 25.1 percent by the end of the 1966-1970 period.[2]

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[1] FAO, The World Sugar Economy in Figures, 1880-1959 (Commodity Reference Series 1, Rome 1961); and FAO, Agricultural Commodity Review and Outlook (Rome: FAO, Various Issues, 1955-1979).

The tendency toward greater self-sufficiency in sugar has had the consequence that the ratio of exports to production of sugar in developing countries fell from 53.6 percent during the 1951-1956 period to 39.7 percent by the end of the 1966-1970 period. However, the share of the developing countries in the world production of sugar remained fairly stable during the same period: this share was 49.6 percent during the 1951-1956 period and 50.4 percent during the 1966-1970 period. Cane and beet are the two main alternative raw materials from which sugar is processed. The share of developing countries in beet sugar production rose from 3.5 percent to 5.0 percent, while their share in cane sugar production remained at 80 percent, during the 1951-1970 period.[3] Developed countries predominate in beet sugar production.

Table 2-1 gives the recent world sugar production and consumption data. However, the consumption figures do not include the sugar used in

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[1] A. Grissa, Structure of the International Sugar Market and Its Impact on Developing Countries (Paris, France: OECD, 1976).

[2] Ibid.

[3] Ibid.

TABLE 2-1

World Production and Consumption[a] Figures, 1960/70-1976

	1960-70 Average	1970	1971	1972	1973	1974	1975	1976
*PRODUCTION	(million tons, raw sugar)							
World Total:	61.06	72.63	72.10	72.13	76.32	80.02	79.31	81.32
(i) Developed Countries:	18.02	20.82	20.64	23.23	22.97	22.30	21.57	24.48
Western Europe	9.41	11.16	10.73	12.48	11.61	12.10	11.15	12.88
North America	4.81	5.18	5.37	5.48	5.96	5.20	5.19	6.46
Others	3.81	4.48	4.64	5.27	5.40	5.00	5.23	5.14
(ii) Developing Countries:	27.93	35.56	34.54	32.89	36.76	39.12	41.51	40.28
Cuba:	5.50	8.43	6.01	4.39	5.35	5.94	6.24	5.69
Other Latin America	12.74	14.03	15.51	15.82	17.03	18.80	18.94	17.94
Far East & Oceania	6.41	8.84	8.54	7.58	9.05	9.82	11.12	11.42
Near East	1.37	1.74	1.95	2.38	2.22	2.19	2.27	2.52
Africa	1.92	2.52	2.53	2.72	2.84	2.94	2.94	2.71
(iii) Centrally Planned Countries:	15.11	16.25	16.92	16.01	16.86	18.03	16.23	16.56
Eastern Europe	4.17	3.80	3.69	3.94	4.41	4.22	4.13	4.43
USSR	8.06	8.85	9.23	8.02	8.32	9.47	7.80	7.70
China	2.89	3.60	4.00	4.05	4.13	4.34	4.30	4.43
*CONSUMPTION[a]	(million tons, raw sugar)							
World Total:	58.80	70.89	72.56	75.11	77.31	78.81	78.07	81.00
(i) Developed Countries:	26.41	29.65	30.23	30.50	31.10	31.37	29.63	30.30
Western Europe	12.42	13.54	14.09	13.89	14.08	14.58	14.54	14.30
North America	10.30	11.37	11.34	11.42	11.67	11.32	10.52	11.00
Others	3.69	4.74	4.80	5.19	5.35	5.47	5.57	5.00
(ii) Developing Countries:	18.54	23.22	24.80	25.63	26.48	27.14	27.88	29.80
Latin America	8.54	10.23	10.54	11.23	11.78	12.20	..	..
Far East & Oceania	5.61	7.44	8.42	8.17	8.10	8.10	..	..
Near East	2.51	3.12	3.33	3.42	3.82	4.40	..	..
Africa	1.89	2.43	2.51	2.81	2.78	2.80	..	..
(iii) Centrally Planned Countries:	14.85	18.02	18.53	18.98	19.73	20.30	20.56	20.90
Eastern Europe	3.42	4.00	4.10	4.04	4.16	4.22	..	..
USSR	8.80	10.20	10.40	10.80	11.20	11.50	..	..
China	2.55	3.54	3.74	3.86	4.10	4.31	..	..
Others	0.24	0.28	0.29	0.28	0.27	0.27	..	..
*CARRY-OVER STOCKS	(million tons, raw sugar)							
World Total:	17.00	21.20	19.00	17.00	15.70	15.90	20.40	11.50

.. Not Available

[a] Excludes consumption in non-food uses, and the sugar in exported products that have not been allocated to individual countries. Therefore, slightly understates the true sugar consumption.

SOURCE: Synthesis from various issues of the FAO, Commodity Review and Outlook (FAO, Rome: 1958-1979).

non-foods and the sugar in exported products that have not been allocated to individual countries from year to year. Hence the consumption figures do not adequately reflect the fact that there have been certain periods when consumption in a given year has greatly exceeded production in that year, leading to high sugar prices, for instance during the early 1970s. Nevertheless, the excluded consumption only contributes a small amount to the total so that the given figures do indicate the general trend in world sugar consumption.

The rate of growth in sugar consumption has been greatest in low-income countries. Depending on the level of per capita income in different countries, regression analysis has shown that income and the retail price of sugar do explain from 60 to 85 percent of the observed variation in sugar consumption among countries. Comparisons of the prices of various food items with the price of sugar over the last three decades indicate that sugar has, on the whole, become cheaper relative to the other foods.[1] Sugar continues to be a major export of developing countries, the major surplus-producing countries being in Central and South America, with Cuba and Brazil as the leading producers.

The overall rates of growth in sugar production and consumption started to decline towards the end of the 1960s. For instance, the average rate of growth in production for the entire period between 1950 and 1970 was 5.6 percent, the corresponding figure for the average rate of growth in consumption being 5.8 percent,[2] whereas the average rate of growth in sugar production for the 1963-1973 period was 3.3 percent, the corresponding figure for the rate of growth in consumption being 3.6 percent.[1] The average annual increases in per capita consumption of sugar for the 1963-1973 period were 13 percent in developed countries (to an average of about 40 kg), 30 percent in the centrally planned countries (to an average of about 43 kg in USSR and Eastern Europe and 4 kg in Mainland China), and 21 percent in developing countries. As the situation stands at present, the general concensus is that the major areas in which sugar consumption can be expected to increase lie in the Mediterranean and African countries. Imposition of various taxation and trade protection measures for sugar in these countries in the past has resulted in high sugar prices which have tended to discourage increased sugar consumption.

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[1] FAO, Monthly Bulletin of Agricultural Economics and Statistics (Vol. 9, No. 1, pp. 1-10; and Vol. 9, No. 2, pp. 1-12). Rome: FAO, 1960.

[2] A. Grissa, op. cit.

The Sugar Marketing Problem and the Organization and Regulation of International Trade in Sugar

The Sugar Marketing Problem

The world sugar market has been characterized by large fluctuations in price for a long time. Overproduction of sugar during certain years has led to depressed prices. The depressed prices have tended to discourage production in the predominantly sugar exporting countries for the period following such prices. On the other hand, underproduction of sugar at certain periods has led to high prices. Such high prices have had a dual role: (i) they have tended to discourage sugar consumption, particularly in the sugar importing countries, while (ii) inducing expansion of production, especially in the sugar exporting countries. The outcome has been a cyclic fluctuation of the quantities of sugar demanded and supplied in the world market. For example, world sugar surpluses during the period 1965-68 led to depressed prices, while acute sugar shortages in the early 1970s led to the highest recorded sugar price in 1974 (see Table 2-2).

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[1] FAO, Agricultural Commodity Projections, 1970-1980, Vol. I (Rome: FAO, 1971), p. 173; and FAO, Commodity Review and Outlook (Rome: FAO, Various Issues, 1955-1979). The percentage growth rate figures are expressed on per annum basis in all cases.

The sharp increases in the world sugar price during the 1970s could be attributed to two phenomena: (i) modifications in the market structure; and (ii) a faster growth in world sugar consumption relative to world sugar production. The modifications in the market structure comprised the enlargement of the EEC, particularly with regard to the accession of Great Britain (UK) to the EEC, and the changed attitude toward developing countries and their opportunities for access to the markets of developed countries. In addition to these factors, renegotiations of sugar trade agreements in general have greatly modified the market structure. The decline in world sugar stocks is another factor that has normally resulted in sharp increases in the price of sugar in the world market. The indications are that the world price tends to increase sharply when the world sugar stocks are less than 25 percent of the world consumption, and that this phenomenon is likely to occur in a cyclical pattern once every decade.[1] Table 2-2 gives the world market prices of sugar for the period 1960-1976, including a summary of the corresponding total sugar production and consumption figures. These figures generally confirm the preceding observation on the movements of the world sugar price.

Gemmill has recently demonstrated that the cycle generated in the world sugar market can be described by the traditional cobweb model, if the model is modified to allow for the generation of long cycles and

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[1] Synthesis from various issues of the FAO Commodity Review and Outlook (Rome: FAO, 1955-1979).

TABLE 2-2

World Sugar Production, Consumption[a] and Carry-Over Stocks and the World Market Sugar Price, 1960-1976

[Production, Consumption and Carry-Over Stocks in Million Tons of Raw Sugar; Price in US Cents per lb., f.o.b. Caribbean Ports].

Year	Production	Consumption	Carry-Over Stocks	Prices
1976	81.3	81.0	11.5	11.50
1975	79.3	78.1	20.4	20.44
1974	80.0	78.8	15.9	29.66
1973	76.3	77.3	15.7	9.45
1972	72.1	75.1	17.0	7.27
1971	72.1	73.4	19.0	4.50
1970	72.6	70.9	21.2	3.68
1969	68.1	68.4	19.3	3.20
1968	66.4	65.5	19.5	1.90
1967	64.7	63.4	19.1	1.87
1966	63.0	61.7	18.6	1.76
1965	66.1	59.8	18.4	2.03
1964	66.3	55.3	9.7	5.72
1963	54.8	47.8	10.3	8.29
1962	51.8	53.4	13.5	3.20
1961	51.8	39.5	18.5	2.90
1960	54.9	52.7	13.4	3.14

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[a] The consumption figure excludes non-food uses of sugar and sugar in exported products not allocated to individual countries during the given year.

SOURCE: Various issues of FAO Community Review and Outlook, (1960-1979); See Table 2-1.

appropriate supply function. The modifications have been based on the postulate that the international supply of sugar is elastic while the international demand for sugar is inelastic.[1]

The incidence of cyclic fluctuations in the quantities of sugar demanded and supplied in the world market has been of major concern to most national governments. This concern is evidenced by the many special arrangements or agreements that have been made between and among nations in an effort to control or regulate the international trade in sugar. Besides, the uncertainty in the world sugar economy has induced many national governments to try and develop their own sugar industries--to the extent that such industries have to be protected by a national policy because the cost of production is in excess of the sugar price that can be obtained at the world sugar market. The pursuit of a self-sufficiency policy in sugar production by many national governments basically aims at avoiding the uncertainty in the world sugar economy.[2]

Organization and Regulation of Sugar Trade

The first international concern over the sugar marketing problem can be traced back to the West European Sugar Convention of 1864, which became the forerunner of the International Sugar Agreements (ISA). The first ISA was signed between the sugar exporting and importing countries in 1937, and this Agreement has been renewed, subject to modifications, five times since then. The ISA is only one of the many agreements or special arrangements that have been made over the years to control or regulate international trade in sugar. In fact, the ISA has now become more important as an instrument of international sugar trade regulation, mainly as a result of the expiry of the United States Sugar Act and the accession of the United Kingdom to the EEC, and will be examined in a separate section.

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[1] G. Gemmill, "Asymmetric Cobwebs and the International Supply of Cane-Sugar," Journal of Agricultural Economics, Vol. 29, No. 1 (UK, 1978), pp. 9-21.

[2] FAO, Commodity Review and Outlook; and FAO, Monthly Bulletin of Agricultural Economics and Statistics (Rome: FAO, Various Issues, 1955-1979).

Many factors interplay to complicate the organization of the world sugar market. First, about 62 percent of the world sugar is produced from cane, the rest being produced from beet.[1] Second, cane sugar is cheaper to produce, but beet sugar production is subsidized or protected by a national policy in many countries, particularly in the Western nations. This pattern results in lack of uniformity in production and the adoption of different trade protection measures among countries. All these factors make the organization of the world sugar market difficult. United Nations Conference on Trade and Development (UNCTAD) has recently been involved in attempts to organize the world sugar market. For instance, the UNCTAD has been responsible for the organization of the United Nations Sugar Conferences, whereby sugar exporters and importers have met to discuss how best to solve the sugar marketing problem. Their commitments have normally been expressed through the ratification of the provisions in the prevailing or pending International Sugar Agreement (ISA).

International trade in sugar has for a long time been organized under the following special markets:

(i) the three large preferential markets, delineated and governed by the United States Sugar Act, the Cuba East Bloc (Socialist Countries) Agreement, and the Commonwealth Sugar Agreement (CSA);

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[1] ISO, International Sugar Colloqium: Official Report (London, 1975)--ISO stands for the International Sugar Organization, whose headquarters are based in London, UK.

(ii) the European Economic Community (EEC) sugar market, governed by the EEC Sugar Marketing Order (a late-comer in the world sugar market scene);

(iii) the residual free world market, governed by the International Sugar Agreement (ISA). The so-called free world market only handles about 10 percent of the total world trade in sugar, while the three large preferential markets handle over 50 percent of the world trade in sugar.

The core of the original EEC sugar marketing order was to establish for the Community (a) a guiding price; (b) a common sugar bureau; (c) a system for skimming off cases of cheap imports from other countries; and (d) a sugar stabilization fund from which export subsidies could be paid. The EEC sugar policy aims at self-sufficiency, with a long-term objective of attaining a net surplus position. This policy is not based on economic grounds and has been criticized as being an example of a situation in which the developed countries have combined to appease domestic pressure groups at the expense of developing countries who could probably supply sugar to the community more cheaply.

Originally, the CSA involved the government of the United Kingdom (UK) and its former dominions or colonies. Such dominions or colonies included Australia, Antigua, Barbados, Jamaica, St. Kitts, St. Lucia, St. Vincent, Trinidad, Guyana, Mauritius, Fiji, Kenya, Uganda, Tanzania, British Honduras, India, Southern Rhodesia (excluded since 1965), and Swaziland. The CSA, which was first signed in 1950 and was operational until 1974, provided for a long-term arrangement for: (i) developing of sugar production in the former British colonies, (ii) orderly marketing of that sugar, and (iii) supply of sugar to the United Kingdom from the surplus producing countries among the CSA signatories. The CSA provided for export quotas and also preferential trade within the Commonwealth countries (formerly British Colonies); it later included preferential sales of sugar to Canada.[1] Among other features of the CSA, the members had to agree on a common price based on sugar production costs. They also had a common undertaking to work for an International Sugar Agreement (ISA). Since the CSA did not provide enough export outlets for its members and about half of their exports had to fall to an unprotected world market, an ISA was seen as an essential concomitant for the CSA. With the United Kingdom's accession to the EEC in 1974, the CSA ceased to operate, but the former signatories of the CSA were offered either associate membership of the EEC, or a trade agreement.[2]

Large fluctuations in the price of sugar in the market, despite the existence of carry-over sugar stocks, do reflect some degree of lack of market co-ordination. The ISA was instituted as an instrument to try and smooth out such fluctuations. However, the nature of the world sugar market is such that only a small proportion of the internationally traded sugar now falls under the jurisdiction of the ISA. For example, about 75 percent of the annual world sugar production is estimated to have been sold in protected domestic markets during the last two decades; about 50 percent of the remainder has been sold under special arrangements, notably the United States Sugar Act (USSA) quotas, the negotiated price quotas of the Commonwealth Sugar Agreement (CSA), and the trade agreements between Cuba and the Centrally-planned or Socialist countries. After the United States diversified its sources of sugar supply following its break with Cuba in 1960, most developing countries who export sugar had one or more preferential export outlets covering the bulk of their sugar exports in most cases.[1]

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[1] D. Jones, "The CSA and the EEC." Bulletin of Oxford University Institute of Economics and Statistics, Vol. 29, No. 3, 1967, pp. 211-232.

[2] See S. Harris and I. Smith, "World Sugar Markets in a State of Flux," Agricultural Trade Paper No. 4, Trade Policy Research Centre, London, UK, 1973.

The situation of trade organization has changed since the expiry of the United States Sugar Act in 1975 and the accession of Great Britain (UK) to the European Economic Community (EEC) in 1974. After these latest developments in the world sugar economy, the world sugar market may now be divided into: (i) Members of the ISA; (ii) Non-members of the ISA who are Net Exporters; and (iii) Non-members of the ISA who are Net Importers in the Free Market. Members of the ISA include (a) countries with basic export tonnages (BET), and (b) countries with export entitlements, such as USSR, GDR, and small exporters. The EEC and the United States now fall under the last two categories of the world sugar market, the EEC having become self-sufficient in sugar in the late 1970s.

The International Sugar Agreement (ISA) and the Latest Developments in the World Sugar Economy

International Sugar Agreements (ISA) have basically regulated the residual market outside the preferential markets governed by special arrangements or agreements as outlined earlier. Although the details of each ISA may have varied from one agreement to another, the main objectives of the ISA have been:[1]

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[1] FAO, Agricultural Commodity Projections: 1970-1980, Vol. I (Rome: FAO, 1971), p. 173.

(i) Price stabilization, usually through price and quota provisions;

(ii) Resolving the imbalance between the production and consumption;

(iii) Devising means to promote and increase sugar consumption;

(iv) Co-ordination of marketing policies;

(v) Observing closely the developments in the use of any form of substitutes for sugar;

(vi) To further international cooperation in sugar questions.

These ISA seem to have worked well, though there have been difficulties in renewing them upon expiry from time to time. For example, the third ISA (signed in 1958) worked well until 1960 when Cuba demanded a higher market share and oversold its quota by more than a million tons: this led to an immediate suspension of the quota and price provision of the 1958 ISA until the next agreement was negotiated in 1968 through the efforts of the UNCTAD.

In the absence of an effective ISA to control sugar supplies, a situation which has occurred from time to time when the signatories to the ISA have been in disagreement, the irregular expansion of production has resulted in wide price variations in the non-preferential world market (i.e., the free world market).[2] The main problem which has weakened the ISA, leading to deadlocks in negotiations at times, appears to stem from the fact that the sugar importers have been in favour of quota and price provision, while the exporters have been opposed to this provision. This problem is evidenced by the failure of the UN Sugar Conference in October 1973 to resolve the differences between the importers and exporters, before the ISA could be renewed. The importers, represented by Canada and Japan, wished to retain the 1968 ISA price levels in the new (1973) ISA, but the exporters wanted to have an increase in price levels. Further, the exporters wished to have the importers indicate purchase commitments in order to set an effective base to the market, but most importers were unwilling to go that far. The smaller exporters were not satisfied with the proposed allocation of quotas in the 1973 ISA proposal. Consequently, the two sides were unable to agree on a range of prices or supply commitment prices, and all that remained of the ISA was an administrative agreement, with no economic clauses. The only agreement that was reached during this conference was the resolution that the International Sugar Council, the Executive Committee and the Secretariat should continue to operate in London for another two years from the beginning of 1974.

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[1] FAO, Monthly Bulletin of Agricultural Economics and Statistics, Vol. 17, No. 12 (Rome: FAO, 1969), pp. 9-12.

[2] FAO, Agricultural Commodity Projections, 1970-1980, Vol. I (Rome: FAO, 1971), p. 173.

The 1973/74 period was a turning point in the history of the world sugar economy. First, the ISA negotiations in October 1973 ended in a deadlock, leaving a weakened ISA which had no economic clauses but was administrative in principle. Second, the CSA ceased to operate in 1974, following the UK's accession to the EEC: the former signatories to the CSA, principally developing countries, were offered the option of either an associate membership or a trade agreement with the EEC. Third, the expanded EEC had to re-define its sugar policy in 1974 so that the new policy could come into operation by the summer of 1975.

The fact that the EEC had not re-defined its sugar policy, primarily due to the anticipation of the problem that the accession of the UK to the EEC and the expiry of the CSA would entail, was largely responsible for the position that the EEC took during the 1973 ISA negotiations. Basically, the EEC wished to enter negotiations as a net importer in any future ISA, despite being virtually one of the largest sugar producers. The EEC's objective was to pursue a production and marketing policy which would keep exports below imports, expecting to be allowed to dispose of its sugar surpluses on the world markets during the periods of generalized world sugar shortages. This objective might explain why the EEC did not sign the 1973 ISA, particularly because the EEC did not agree with the import quota allocations. Finally, the highest recorded real price for sugar was experienced in 1974 due to the high demand for sugar, which was coupled with generalized sugar shortages in the world markets during this year.[1]

A series of steps were taken in an effort to solve some of the sugar problems experienced during the 1973/74 period. First, a meeting was convened in February 1975 in order to re-define and strengthen trading relations between the former signatories to the CSA and EEC. This meeting came to be called the Lomé Convention of 1975 between the EEC and 46 ACP (African, Caribbean and Pacific) countries.[2] The meeting focused on: (i) trade cooperation; (ii) stabilization of export earnings, particularly those from sugar; (iii) industrial co-operation; and (iv) financial and technical co-operation. An important outcome of this convention was the agreement that ACP agricultural exports could either have free access to the EEC market if they fell under the common agricultural policy (CAP) of the EEC, or be covered under preferential schemes. Similar trade concessions were offered to the ACP, but the ACP states had to guarantee the EEC treatment as good as the most favoured nation in their trading, with no discrimination between member states.

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[1] Synthesis from various issues of the FAO, Monthly Bulletin of Agricultural Economics and Statistics and the FAO, Commodity Review and Outlook (Rome: FAO, 1955-1979).

[2] See FAO, Commodity Review and Outlook (Rome: FAO, 1974/75), pp. 35-36.

The second major step taken to solve the sugar problem after 1974 was the initiation of negotiations for a 1977 ISA, to replace the crippled 1973 ISA which had no economic clauses. Since the CSA had become defunct with the accession of the UK to the EEC and the terms of UK's relationship with the former CSA signatories had been re-defined, the EEC would have been expected to be compromising during the negotiations for the 1977 ISA. Further, the United States sugar Act had expired by 1975, and the United States was expected to be a chief negotiator in the 1977 ISA conference. The draft of provisions for the sugar conference had been in preparation since the 1973 conference failed to achieve an effective ISA.

The final draft of the 1977 ISA proposals included the following provisions:

(1) an agreed price range from US $245 to $470 per ton (about UK £136 to £261 per ton);[1]

(2) a reserve stock of 2.5 million tons held by quota-holding (exporting) members of the agreement under the control of the International Sugar Organization;

(3) the creation of stocks is to be paid for by importers through a fee (of from 0.50¢ to 0.75¢ per lb) to be paid on all imports of sugar

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[1] The literature does not explain whether the term ton refers to the imperial or metric ton in most cases. One can assume that the term is used to refer to the metric ton unless otherwise specified.

or on exports to non-ISA member countries: the fund raised will provide interest-free loans to exporters to cover the cost of carrying stocks;

(4) fixing of Basic Export Tonnages (BET) for individual countries (this was the most difficult issue), i.e., the quota provisions.

When compared with the previous Agreements, the ISA of 1977 is more flexible in many regulations. For instance, the obligations of importing and exporting member countries of the ISA to support quota and stock mechanisms is now more relaxed, and the so-called basic export tonnages (BET) are generously distributed; they even exceeded the net world import requirements in 1978 by 35 percent. BET are the export entitlements to producers under the ISA and it makes no economic sense to have BET in excess of net world import requirements. This move toward increased flexibility in the ISA (1977) was intended to induce more participants in the negotiations to ratify the Agreement. However, the move can also be expected to weaken the effectiveness of the Agreement, although the 1977 ISA and its provisions can be said to reflect the structural changes and problems of the 1970s which have necessitated the consideration of more flexibility in future Agreements.

The main objective of the 1977 ISA can be summarized as: (1) to provide secure supplies of sugar for consuming countries; and (2) to stabilize prices of sugar between US $245 and $470 per ton (equivalent to UK£136 and £261 per ton). Despite the greater flexibility of the 1977 ISA, the EEC and its ACP partners in the Lomé Convention did not sign the ISA because the EEC was still trying to solve some internal policy conflicts. The EEC Commission's original proposal for limitation of EEC exports was not accepted by the EEC Council, following France's opposition on the grounds that the EEC would not be able to dispose of the million tons of sugar surplus if its exports were restricted. Basically, the EEC would have liked to have an export quota fixed under the 1977 ISA which allows for the disposal of the 1.3 million tons of sugar imported under the Lomé Convention. However, the ISA price range of $245-$470 compares favourably with the EEC's basic intervention price of $305 and a $288 guaranteed import price to ACP countries, so that, under the terms of the current ISA, the EEC and its ACP partners in the Lomé Convention may be expected to sign the ISA at any time.

In addition to the EEC and its ACP partners in the Lomé Convention, the United States was another disappointment for the 1977 ISA negotiations. The United States also failed to ratify the 1977 ISA. The failure of the United States to ratify the 1977 ISA is of interest for two reasons: (i) the United States is the greatest importer of sugar in the world; and (ii) the corn sweeteners industry has grown relatively fast, and this industry now provides about 26 percent of the United States sweeteners market, the consequence being that the United States imports of sugar dropped by 30.5 percent in 1978.[1]

The policies or programs which the United States adopts in 1979 and onwards are likely to have a major impact on the growth and stability of the world sugar market. The already chronic problem of price fluctuations could be exacerbated by the threat of new competition from high fructose corn syrup (HFCS), the corn sweetener, whose production is being protected and expanded in the United States. The United States is not expected to ratify or declare its position with regard to the 1977 ISA before its domestic sugar policy is considered by the Congress during and after 1979. However, the United States signed a proclamation limiting sugar imports from non-ISA members at the end of November 1978. The proclamation allows the United States to import small amounts of sugar from non-ISA members, but this move is seen as supporting the general cause of the ISA.[1]

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[1] N. Rivero, "Sugar and the US Congress in 1979," World Sugar Journal, Vol. 1, No. 8 (1979), pp. 14-16.

In spite of the few disappointments that have been cited for the 1977 ISA negotiations, the 1977 ISA was signed by 72 sugar importing and exporting countries. This agreement became effective in January 1978 and will remain in effect for a five year term. During that period, the agreement is expected to affect about 14 million tons of sugar, which constitutes about 14 percent of the world sugar production. Since sugar is a major export of developing countries, such countries could benefit by having access to the markets of developed countries. This point has been of greater consideration in recent UN Sugar Conferences, and is expected to become a major clause in future ISA negotiations.

The World Sugar Economy: An Assessment and Outlook

The ISA of 1977 purports to regulate the world sugar market by controlling the quantities of sugar exports (regulation of supply). This objective is to be achieved through the operation of a Special Stock Fund (SSF) which will be used to finance carry-over stocks of sugar in major exporting countries.[2] The current Agreement has been in operation for about two years already, and preliminary effects of its presence can be assessed. The present situation (1979) is one of surplus: producer countries have invested heavily in developing production but consumption has stagnated in developed countries, though new market openings exist in some developing countries, such as China. At the end of the marketing year 1977/78, the world sugar stocks were at their highest level since the last 25 years. Large amounts of sugar stocks were still carried over in the 1978/79 crop year.[1]

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[1] Ibid.

[2] See "Sugar in the Year 1978," Sugar Review, No. 1420 (UK, 1978), pp. 249-264.

Despite the large amounts of sugar stocks which were carried over during the 1977/78 and 1978/79 marketing years, the world sugar market remained relatively stable for the following reasons: (i) nearly 40 percent of the sugar carry-over stocks were put aside as special stocks under the ISA, while (ii) about 50 percent of the carry-over stocks were in the hands of the members of the ISA, so that only about 10 percent of the carry-over stocks actually overhung the market.[2] The downward pressure of the world sugar market is likely to be limited as long as (i) the ISA remains in effect, (ii) countries with high sugar stocks remain members of the ISA, and (iii) non-members of ISA, such as the EEC, do not expand sugar production. However, there are doubts if the market-stabilizing conditions given above will be met fully, especially in the wake of expansion of sugar projects in the developing countries that trade with the EEC under the Lomé Convention provisions.[3]

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[1] N. Osman, "Special Stocks Under the International Sugar Agreement: Stocks Not a Threat to the Stability of the Market," World Sugar Journal, Vol. 1, No. 10 (1979), pp. 15-17.

[2] Ibid.

[3] See Commission of European Communities, Inconsistencies in the Policies Pursued by the Community and Member States: The Example of Sugar (Information Memo, Spokesman's Group, EC [1978] No. P-130, 7 pp.

Expansion of sugar production by the ACP members states that trade with the EEC under the Lomé Convention provisions is partly to be blamed on the EEC sugar policy. The quotas and prices fixed under the current EEC policy were formulated in an endeavour to make EEC self-sufficient in sugar supply, and the consequence has been such that the ACP countries have reacted to these quotas and prices by expanding sugar projects. Hence the sugar imported in the EEC under the ACP sugar agreement will have to be re-exported on the free world market, which should have a price dampening effect on the world sugar market. The Commission of the EEC thus calls for full co-ordination of all industrial investments which member states of EEC might support in developing countries, either directly or indirectly, in order to ease marketing problems.[1]

An assessment of the sugar balance in 1979 under the ISA shows that the world sugar market will increasingly become a political market: (i) the question of the EEC's relationship with the ISA, and the extent of the subsidized export to the free world market, and (ii) the question of the US ratification of the ISA will both have fundamental ramifications on the world sugar market. So far, prices have not reacted favourably to the ISA quota provisions, and this can partly be attributed to the actions of the US and the EEC. Despite being one of the major net importers of sugar, the United States is known to hold large carry-over stocks of sugar from year to year.[2]

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[1] Ibid. The developing countries that trade with EEC under Lomé Convention provisions are referred to as the ACP countries.

[2] N.G. Osman, "An Assessment: Sugar Balance in 1979 Under the ISA," World Sugar Journal, Vol. 1, No. 5 (1978), pp. 14-19.

The current (1979) sugar situation may be described as one of surplus. Yet there are some factors which will influence and change this situation drastically. These include: (i) the emergence of the USSR and China as free market importers of sugar, (ii) the trends in prices of other commodities, particularly for oil, (iii) structural changes in the market, for instance, those arising from the policies and programs to be pursued by the US and the EEC, (iv) trends in the price of sugar itself, and (v) the inherent competition that sugar is likely to face from other sweeteners, particularly from isomerose (the HFCS, or the corn-sweetener). In the face of all these factors, there are predictions that there could be a sugar undersupply situation, leading to a disequilibrium similar to the one that contributed to the rapid price increase in 1974/75. Such a disequilibrium is likely to lead to a high sugar price by 1985.[1]

Summary and Concluding Remarks on the World Sugar Economy

The world sugar economy has had extensive structural changes during the 1960s and 1970s. Among the factors influencing the structure of the sugar economy, the 1960 US boycott on Cuban sugar imports was the most influential single factor. The flexibility of the international sugar market was demonstrated by the swift response by Mexico, Latin America and Australia to supply the US. However, the US boycott failed to paralyse the Cuban economy: Cuba entered a long-term agreement with the socialist countries, who offered to buy the 3 million tons of sugar which were formerly required by the US, and the importance of the socialist countries increased in production and marketing of sugar in the 1960s. Another feature of the developments in the 1960s is the fact that the contribution of developed countries in sugar production has been increasing steadily. Overall, sugar production increased faster than consumption during the 1960s, and a growing tendency toward self-sufficiency emerged. The trading union between Cuba and the other socialist countries increased the amount of sugar trade falling under special trading arrangements, thus decreasing the importance of the free market for sugar (governed by ISA) as a means of controlling prices.[1]

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[1] L.C. Hurt, et. al., An Update on World Sugar Supply and Demand: 1980 and 1985 (USDA, Foreign Agricultural Service, Washington, D.C., 1978), 30 pp. The forecast prices are 15.8¢ per lb in 1980 and 20.2¢ per lb in 1985, when compared with the ISA floor price of 11¢ per lb in 1978.

Important structural changes and problems of the 1970s include (i) the expiry of the CSA, following the accession of the UK to the EEC in 1974; (ii) the provisions of the Lomé Convention, which guaranteed the former signatories to the CSA (i.e., the ACP member states) a market for their sugar in the EEC; (iii) the expiry of the US Sugar Act in 1975; and (iv) the emergence of USSR and China as sugar importers in the free world market.

The existence of special trading arrangements between importing countries and their suppliers has characterized the world sugar economy for a long time. Until the end of 1974, the most important of these special arrangements were those covering the negotiated price and quota exports to the UK under the CSA with effect from 1950, the Cuban exports to the socialist countries, and exports of sugar to the US (governed by the US Sugar Act). The free world market continues to be controlled by successive ISA's, whose mandate has continued to be weakened over time. For example, the 1973 ISA had only information gathering and consultative functions; no provisions on regulatory functions could be made following the failure of the 1973 UN Sugar Conference (on the renewal of the 1968 ISA) to reconcile the differences between exporters and importers with respect to price provisions. The latest (1977) ISA, which became operational at the beginning of 1978, will be effective for a five year period; the main provision of this agreement is for secure supplies of sugar for the consuming countries and at stable prices between UK £136 and £261 (about US $245 and $470) per ton.

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[1] See Hagelberg, G.B., "Sugar." In Payer, C., ed., Commodity Trade of the Third World (London: MacMillan, 1975), pp. 104-128.

A major drawback in the ISA negotiations in 1977 was the failure of the US (the greatest net importer of sugar in the world market) and the EEC (a major net importer of sugar, but also an exporter at times) to ratify the 1977 ISA. The actions of the US and the EEC can be expected to compound the problem of international sugar marketing in the future. The EEC, which imports sugar from the ACP countries under the provisions of Lomé Convention, is virtually self-sufficient in sugar supply, and will likely re-export the sugar from the ACP countries in the free world market, thus dampening the world market price.

As far as the world sugar economy is concerned, one can conclude that:

(i) The level of sugar production in many countries is not always the right indicator of the export potential; some large volume producers, such as the EEC, have high imports themselves; and

(ii) The presence or absence of special trade arrangements, coupled with political motivations, has led to some marketing inefficiencies. For instance, the bulk of Cuban export goes to socialist countries, leaving a sizeable share of the US imports to be met from the distant Philippines. Hence the abandonment of all trade agreements could be expected to lead to some improvements in marketing efficiency. However, the growing tendency toward self-sufficiency production in many countries may be an indicator that trade agreements and protectionism in sugar trade are unlikely to be abandoned in favour of a free world trade.

The dynamics of international politics has also weakened the effectiveness of ISA as the instrument for regulating the free world market for sugar. However, any international commodity agreement, such as the ISA, is reached after taking into account the interests of both importing and exporting countries. Hence the avoidance of politics in a regulated or controlled commodity market is virtually impossible.

The prevalence of protection measures for sugar trade in many countries can be expected to lead to economic inefficiency in terms of resource misallocation because production and trade are not allowed to proceed according to the principle of comparative advantage. Given that the sugar producers who have greatest comparative advantage are developing countries, then sugar protectionism, which is prevalent in developed countries, can be expected to result in the reduction of export earnings of developing countries.[1]

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[1] A number of empirical studies have examined and assessed the implications and the costs of protectionism in the sugar trade. Notable examples include: (i) R.H. Snape, "Some Effects of Protection in the World Sugar Industry." Economica, Vol. 30 (1963); (ii) H.G. Johnson, "Sugar Protectionism and the Export Earnings of Less-Developed Countries: A Variation of the Theme by R.H. Snape." Economica (1966); and (iii) R.H. Snape, "Sugar: Costs of Protection and Taxation." Economica, Vol. 36 (1969). Some of the specific aspects of these studies will be reviewed in the ensuing discussion of relevant economic literature on the sugar industry in the world.

The Review of Specific Economic Literature on the Sugar Industry in the World

Introduction

The review of economic literature on the sugar industry in Kenya will be presented in the next chapter under the appropriate section. The purpose of this section is to present a review of the findings from some studies on the sugar industry in other parts of the world. Such findings are considered useful in the evaluation of the results of this study.

Literature on the Sugar Industry in Individual Countries

Most of the available relevant literature on the sugar industry in individual countries relates to dissertation studies carried out in the Universities, mainly in the United States of America (the US). Such studies[1] have covered a wide cross-section of countries and topics so that their findings are of interest to researchers and can be useful as guidelines on what problems or specific aspects of the sugar industry require further investigation. The review gives some selected aspects of the various studies that are cited, the choice of the aspects to be included being based on the perceived relevance to this study.

In a study of the North India's sugar industry, Hirch (1959) gives a description of the industry and analyzes the procurement and marketing problems.[2] Hirch's study emphasizes the production of jaggery[3] and other sweetening products, which are of little relevance to the situation in Kenya. However, the study merits some mention since it discusses jaggery production, which is often ignored in most studies on sugar. Jaggery production is known to be a competitive alternative to sugar production in Western Kenya, but its production is discouraged by the Government.[1]

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[1] Such studies are cited by author and date of study in the review since the full text of the reference is given in the list of references for the thesis.

[2] L.V. Hirch, Marketing in an Underdeveloped Economy: The North Indian Sugar Industry (The Ford Foundation Doctoral Dissertation Series, 1960 Award Winner; Englewood Cliffs, N.J.: Prentice Hall, Inc., 1959).

[3] Jaggery is a noncentrifugal form of sugar, made principally by crystallizing the cane syrup.

A general survey of the sugar industries in Africa is given by Smith (1976) in the fifth volume of a series of five volumes entitled "Sugar Y Azucar Yearbooks," published by the Sugar Y Azucar Journal, with D. Smith as the general editor. In the section that examines the sugar industry in Kenya, Smith (1976) notes and discusses briefly all the problems presented and discussed by M.O. Odhiambo (1978) in a study which will be reviewed under the section on the literature on the sugar industry in Kenya. Generally, Smith's review is based on information gathered during his extensive tour of the sugar industries in Africa and lacks analytical substance.

In a study of the economic, technical and institutional factors that had influenced the decline of the beet sugar industry in the Eastern Region of the United States, Young (1963) found that the fixed beet and sugar prices, coupled with the rising cost of labour, had adversely affected both the beet and sugar production. There was no economic incentive for beet producers to intensify production, or for processors to erect new factories should beet production increase. The farmers had shifted to mechanized production to reduce labour costs, and this had led to the production of lower quality beets. Since beet production was the best-suited crop enterprise on the heavy lake-bed soils in the region, Young concluded that beet supplies could be expected to remain steady or even increase, despite the unfavourable producer prices.

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[1] Personal Communication, Provincial Agricultural Officers (Crops), Nyanza and Western Provinces of Kenya, 1976.

Wen-Fu (1966) evaluated the sugar pricing policy and its influence on cane supplies in Taiwan, where prices were fixed by the government. He found that the farmers' decision to produce cane was influenced both by the sugar price and by nonprice factors, such as the land type and its suitability for production of cane and some other crops. A related study by Chwei-Lin (1967) demonstrated that cane production in Taiwan was more sensitive to economic factors than the production of rice, the alternative major crop, was so that pricing could be used to regulate production.

In an analysis of the beet sugar industry in Montana, United States, Godfrey (1969) showed that alternative beet prices could be used to regulate beet production in the United States. The analysis by Raquibuzzaman (1970) of the economic implications of alternative sugar policies which could be adopted by developed countries, especially by the United States, indicated that a policy of complete free world trade in sugar could bring tremendous benefits to the developing countries at a relatively negligible cost to the developed countries. Hence he suggested that the high-cost sugar producers should adopt a policy which would limit their sugar production to the existing level, agreeing to import all future increases in their demand for sugar from the low-cost producers. A study of the effects of the United States Sugar Act and its import quotas by Sanchez (1972) indicated that the quota system leads to inefficiency in the world allocation of resources in sugar production. Since the behaviour of all countries at the international level can be taken as competitive, regardless of the market structures within individual countries, then a policy of free world trade could be expected to lead to a more efficient allocation of the world resources to sugar production.

A study of the cost structure of cane production in Sao Paulo, Brazil, by Hughes (1971) showed that farms producing less than 500 tons of cane had the highest average total cost per ton; those producing 500 to 10,000 tons of cane had the lowest average total cost per ton, while those producing over 10,000 tons of cane had slightly higher average total cost per ton. These results suggest that there are some scale economies in cane production. Hughes estimated that about 60 percent of the average total cost in cane production was contributed by variable costs; he also showed that the size of the farm did not totally explain the observed farm cost structure. The important cost variables were depreciation, labour (especially at cutting and loading), seed and fertilizers, and interest on the land investment.

An analysis of the locational aspects of the United States sugar industry by Flores (1972) showed that the total interregional transportation cost of marketing could be minimized by re-allocation of trading patterns. The study also indicated that any attempts by the United States to move towards self-sufficiency in sugar production would lead to increases in the average cost of production and the interregional transportation cost of marketing, since only the North Central area of the United States is suitable for sugar production. Consequently, the average regional price of sugar would be expected to increase.

Specific Literature on the World Sugar Economy

The general review of the world sugar economy has been presented in the earlier sections of the chapter. The purpose of this section is to examine and present specific aspects of the studies on the world sugar economy which are considered useful in the assessment of the results of this study.

The spatial-equilibrium approach to the analysis of the world sugar market was first done by Thomas Bates in 1965. Bates (1965) showed that the prevailing pattern of international sugar trade was inefficient and that the United States was not importing sugar from its lowest-cost source. Freer world trade in sugar would generally lead to lower sugar prices. A similar conclusion was reached in a study by Sanchez (1972), as reviewed earlier. The question of gains to developing countries from a freer international trade in sugar has been examined since 1963. The works of R.H. Snape (1963 and 1969), Harry Johnson (1966) and D. Gale Johnson (1974) all focus on the impact of the domestic sugar programs, and other agricultural protection programs in general, on the global economic efficiency and the implications for social welfare. The results of such studies generally justify the case for a freer world trade in agricultural products. D. Gale Johnson (1974) actually demonstrates that there are substantial income transfers from the less developed countries (LDC) to the developed countries owing to the protectionist programs in such developed countries.[1]

Few studies appear to have been conducted to estimate world price elasticities of supply and demand for sugar. Most studies at the global level have tended to focus on, and estimate, the rates of growth in production and consumption of sugar, the major works in this area being those of the FAO (1961) and A. Viton and F. Pignalosa (1961). Other studies have focussed on the uncertainties facing the world sugar economy, as exemplified by the studies of Timonshenko and Swerling (1957) and Hagelberg and Harris (1976). The main theme of the paper by Timonshenko and Swerling (1957) is that sugar can be expected to suffer the same effects of general deflation or inflation of commodity prices. A more detailed review of the uncertainties facing the world sugar economy has been presented in earlier sections of the chapter, but the contributing factors were not discussed. Hagelberg and Harris (1976) identify the following factors as the crucial uncertainties in the world sugar economy:

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[1] The specific studies are: (i) T.H. Bates, The World Sugar Economy and the U.S. Supply Policy (Unpublished Ph.D. Thesis, University of California, Berkeley, 1965); (ii) R.H. Snape, "Some Effects of Protection in the World Sugar Industry," Economica, Vol. 30 (1963), pp. 63-73; and (iii) R.H. Snape, "Sugar: Costs of Protection and Taxation," Economica, Vol. 36 (1969), pp. 29-41; (iv) H.G. Johnson, "Sugar Protectionism and the Export Earnings of LDC: Variations on a Theme by R.H. Snape," Economica, Vol. 33 (1966), pp. 34-42; and (v) D. Gale Johnson, The Sugar Program: Large Costs and Small Benefits (Washington, D.C., America Enterprise Institute, 1974).

(i) Arbitrary changes in government policy;

(ii) Unpredictability of sugar developments in individual countries; and

(iii) Absence of regular and reliable sugar forecasts. These are also some of the problems highlighted and discussed during the International Sugar Colloquium in London in 1975, whose proceedings were presented in an official report (1975).[1]

A recent study by Gemmill (1976) has made estimates of elasticities for supply and demand of sugar on a global basis. The study estimates that the United States of America (U.S.) and the European Economic Community (EEC) have elastic supply responses for beet-sugar of 1.74 and 1.04 respectively, while the Communist nations have inelastic supply responses of 0.3 for the beet-sugar. For cane-sugar, the U.S. is estimated to have a supply elasticity of 1.57, while the elasticities for the major world cane producers are estimated to be low (about 0.3) under falling prices and slightly higher (up to 1.0) under high and rising prices. Demand elasticities for sugar in the 73 countries examined by Gemmill (1976) range from 2.0 to 0.0 for income and from -1.5 to 0.0 for price.[1]

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[1] The specific studies are: (i) V.P. Timonshenko and Swerling, The World's Sugar Progress and Policy (Stanford, California: Stanford University Press, 1957); (ii) G.B. Hagelberg and S.A. Harris, "Pluralism and Uncertainty in the World Sugar Economy," Food Policy Journal, Vol. 1, No. 4 (1976) (IPC Business Press Ltd., Surrey, England, 1976); (iii) FAO, "The World Sugar Economy in Figures, 1880 to 1959," Commodity Reference Series 1 (FAO, Rome, 1961); and (iv) A. Viton and F. Pignalosa, "Trends and Forces of World Sugar Consumption," Commodity Bulletin Series 32 (FAO, Rome, 1961). The Official Report of the International Sugar Colloquium in London in 1975 was published by the International Sugar Organization in 1975.

The findings cited from the study by Gemmill (1976) have important implications since they do give the structural variables for the major markets for sugar: the policies of the U.S., EEC and the Communist nations with regard to sugar can be expected to have great impact on the world sugar market. The major sugar producers who export on the world market are known to have considered the formation of a sugar cartel as a means to raise their export earnings, particularly in the face of the past ill-functioning International Sugar Agreements (ISA) and being encouraged by the apparent success of the oil exporters' (OPEC) cartel. The major sugar exporters happen to be developing countries, whose major raw material for sugar production is the cane. From the elasticities estimates made by Gemmill (1976), it appears that a sugar cartel cannot be very effective, given the relatively elastic supply of beet sugar in the major sugar importing nations of the Western world.

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[1] G. Gemmill, "The World Sugar Economy: An Econometric Analysis of Production and Policies," Agricultural Economics Report No. 313, Department of Agricultural Economics, Michigan State University (1976) (the Report is based on Gemmill's Ph.D. Thesis, M.S.U., 1976).

In his study, Gemmill (1976) uses the spatial-equilibrium modelling technique, as developed and applied by Bateman (1965), in the analysis of the world sugar market. Apart from his estimates of the supply and demand elasticities, Gemmill (1976) also estimates gains and losses accruing both to exporters and importers of sugar from alternative policies. He finds that the total volume of world sugar production is relatively stable under all policies and concludes that this is a reflection of two factors: (i) that there is ease of substitution of beet-sugar for cane-sugar; and (ii) that the prevailing international sugar quotas distort the pattern of trade in sugar rather than actually reduce such trade. He then estimates that a universal free trade in sugar could lead to a net positive international gain of about 8 percent of the value of trade in sugar, this being an accrual mainly from a more rational pattern of transportation.

Concluding Remarks on the World Literature on Sugar

The literature reviewed suggests that sugar production is relatively more responsive to price changes than the production of the alternative competing agricultural products. Non-price factors such as land type and climate are also important in influencing production decisions by farmers. Hence fixed prices could have adverse effects on the supply of sugar. The previous studies also suggest that the pursuit of a self-sufficiency policy for sugar production could lead to a high average sugar price, unless production is based on comparative advantage viz-a-viz other world sugar producers.

Generally, a freer world trade in sugar would result in net positive benefits both to importers and exporters of sugar. However, such a move is hindered by national policies of trading partners. The study by Gemmill (1976) shows that the formation of a sugar cartel would be inopportune. Such a move would not be expected to improve the problems of international trade in sugar. However, a buffer-stock type of program could smooth out short-run fluctuations in the world sugar price and possibly stabilize the export earnings of the major sugar producers.

CHAPTER III

A SYNOPSIS ON AGRICULTURAL DEVELOPMENT AND THE SUGAR INDUSTRY IN KENYA

The Role of Agriculture and Agricultural Development Policy In Kenya

The agricultural sector continues to play the major role in the economic development of Kenya. The sector has continued to contribute about 30 to 40 percent of gross domestic product (GDP) since the late 1950s. About 80 percent of the population of Kenya still earns its livelihood from agriculture, and agricultural exports have made up about 70 percent of Kenya's total exports in recent years.[1] The major agricultural commodities of Kenya include coffee, tea, beef, milk, maize, sugar, wheat, sisal, pyrethrum, barley, rice, cashew nuts, beans and pineapple. Tea, rice, sugar (from cane), maize, coffee, and pineapple have shown large increases in production over the last two decades. However, agricultural imports have grown faster than the agricultural exports during the same period. The major agricultural imports have continued to be sugar, fats and oils, and wheat.[2]

During the times of the colonial government in Kenya (prior to 1963), agricultural development was basically limited to the Kenya Highlands, a region of the greatest cash crop production potential, which had been occupied by British settlers. This trend continued for a long time. There were no plans for a country-wide development of agriculture until 1954 when the colonial government realized the need to develop agriculture, with an emphasis on the intensification of agriculture by the native African populace, under the so-called Swynnerton Plan. The second phase of agricultural development in Kenya began with the attainment of political independence in 1963.

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[1] J. Heyer, J.K. Maitha and W.M. Senga, eds. Agricultural Development in Kenya: An Economic Assessment (Nairobi: Oxford University Press, 1976), pp. 1-110.

[2] See, for example, L.A. Witucki, Agricultural Development in Kenya Since 1967, Economic Research Service, USDA, Washington, July 1976.

Realizing the potential of the agricultural sector, particularly as an employer of the fast-growing population in Kenya, the new (African) government that took office in 1963 embarked on a number of agricultural development project. The Government has continued to plan and implement agricultural development programs since then. The major policy goals of the agricultural development plan in Kenya can be summarized as follows:[1]

(a) To improve and increase agricultural production through intensified use of resources;

(b) To improve the distribution of rural income through the promotion of cash crop production;

(c) To devise methods of developing the low potential areas and to promote a more even development among different regions of the country;

(d) To improve the nutrition standard in the rural areas;

(e) To increase the opportunities for employment in the agricultural sector;

(f) To attain self-sufficiency in food supply and increase agricultural exports.

The specific targets for the agricultural sector during 1977/78 Plan period were (i) to achieve a 6.7 percent growth in marketed production; (ii) to raise the proportion of farmers who obtain a cash income from their land; and (iii) to achieve a more equitable development among different areas of the country. Self-sufficiency in food supply is deemed desirable so that Kenya can save on foreign exchange that would normally go to food imports and thus deplete the scarce resources that are needed for local development projects.[1]

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[1] Government of Kenya, Development Plan, 1974/78 (Nairobi: Government Printer, 1974).

Sugar Production in Kenya

Introduction

Background information on Kenya's sugar industry was presented in Chapter I. The purpose of this section is to describe the chief features of production, highlighting production levels and organization of sugar production. The major alternative enterprises to sugar production in the main cane production zones are then presented in order to demonstrate the competitiveness of sugar production in the zones concerned. A map of Kenya showing the existing and proposed sugar schemes in Kenya by the end of 1977 is given in Figure 3-1.

Production Levels and Industry Organization

The sugar mills in Kenya have been characterized by excess capacity for a long time. Although the five mills are capable of processing about 285,000 metric tons of sugar annually, only about 70 percent of this capacity is being utilized at present.[2] The mill capacities depend upon initial design and addition of new equipment or replacement and

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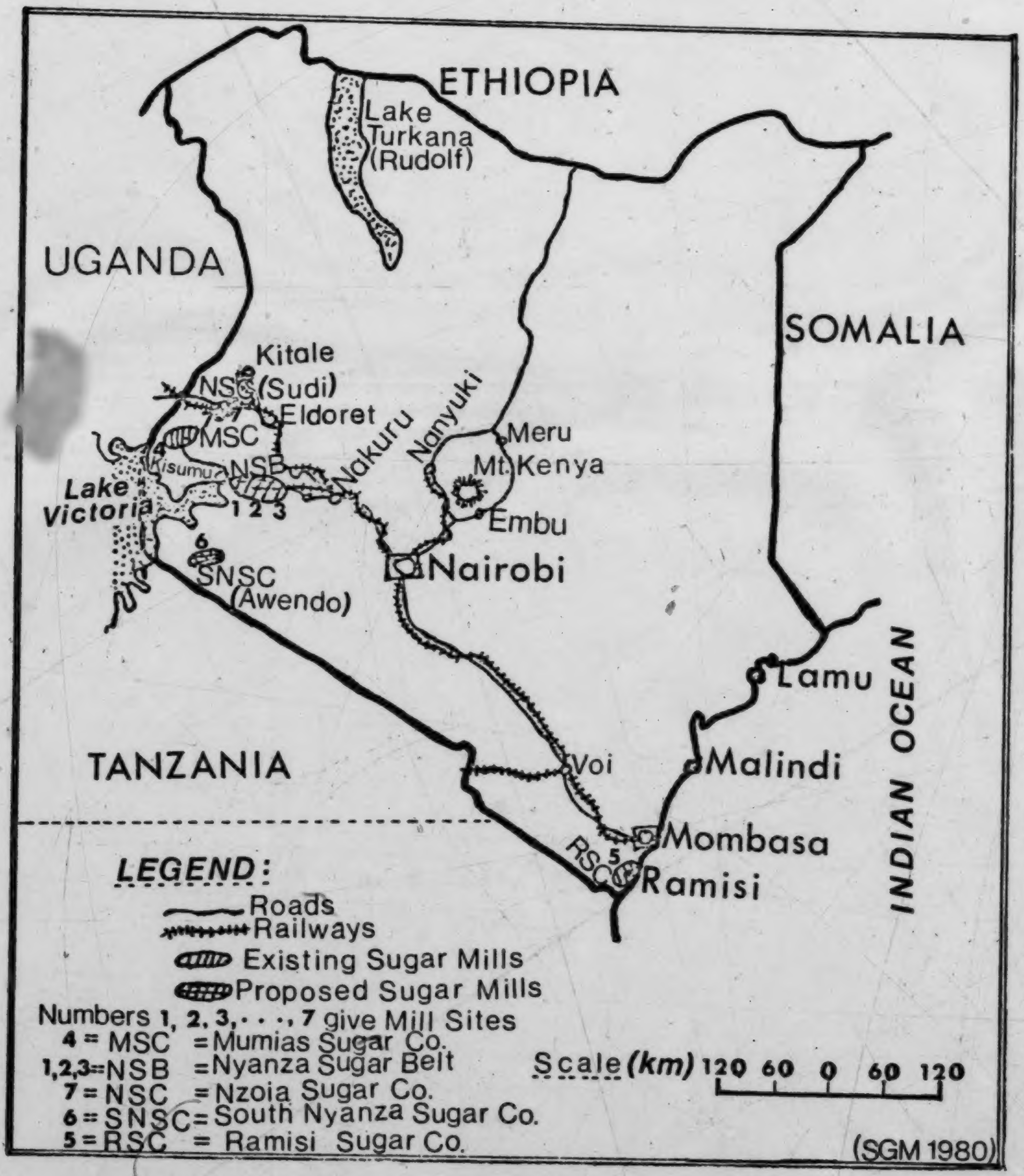
[1] *Ibid*.

[2] Based on the sugar production estimates for 1976 and 1977 at 190,000 and 205,000 metric tons respectively, and the rated annual mill processing capacities.

FIGURE 3-1

MAP OF KENYA SHOWING THE EXISTING AND THE PROPOSED SUGAR SCHEMES BY THE END OF 1977


ETHIOPIA
Lake Turkana (Rudolf)
UGANDA
SOMALIA
Kitale
NSC (Sudi)
7
Eldoret
MSC
4
Kisumu
NSB
Lake Victoria
1 2 3
Nakuru
Nanyuki
Meru
Mt. Kenya
Embu
6
SNSC (Awendo)
Nairobi
Lamu
TANZANIA
Voi
Malindi
INDIAN OCEAN
Mombasa
5
RSC
Ramisi
LEGEND:
Roads
Railways
Existing Sugar Mills
Proposed Sugar Mills
Numbers 1, 2, 3, . . ., 7 give Mill Sites
4 = MSC = Mumias Sugar Co.
1,2,3 = NSB = Nyanza Sugar Belt
7 = NSC = Nzoia Sugar Co.
6 = SNSC = South Nyanza Sugar Co.
5 = RSC = Ramisi Sugar Co.
Scale (km) 120 60 0 60 120
(SGM 1980)

renovations. Table 3-1 gives the capacities of the current number of sugar mills, based on their rated annual processing potential.

TABLE 3-1

Annual Sugar Mill Capacities

Mill	Metric Tons Mill-White Sugar Per Annum
Mumias	70,000
Muhoroni	60,000
Chemilil	65,000
Miwani	60,000
Ramisi	30,000
TOTAL	285,000

SOURCE: Ministry of Agriculture, Economic Review of Agriculture, January-March, 1975 (Nairobi: Government Printer, 1975).

Cane production is presently organized on the basis of a nucleus estate and the outgrowers. The nucleus estate is a cane plantation which is directly controlled by a given sugar scheme or complex, to supply a given mill with the cane. The size of the mill-controlled plantation varies between 5,000 and 12,000 acres (2,024-4,858 hectares); in some cases, the mill personnel supervises additional large farms to give the mill further control over cane production. The term outgrowers refers to all cane producers who supply the sugar mill with cane but are not directly controlled by the mill management.

Outgrowers comprise large-scale farmers having from 40 up to 1620 hectares of land under cane production and small-scale producers who normally have from 1 to 6 hectares of land under a cane crop. The small-scale producers are the largest group of outgrowers, and these may be organized to supply cane to the given mill either as members of a co-operative society, a settlement scheme or a private company. The Government policy on cane production has been one whereby small-scale production is promoted in order to ensure that the proportion of farmers getting cash income from farms is increased. Besides, this production policy can ensure that more people will get employment in agriculture. Table 3-2 gives the cane acreage distribution by the type of grower for the five sugar mills in 1975.

TABLE 3-2

Land Under Cane Production: Estimates by Type of Producer in 1975 [Hectares]

Mill	Nucleus Estate	Large Growers	Small Growers	TOTAL
Mumias	3,239	-	8,097	11,336
Chemilil	2,834	6,478	3,644	12,956
Muhoroni	2,024	1,215	6,478	9,717
Miwani	3,239	5,668	1,619	10,526
Ramisi	4,848	202	810	5,870

SOURCE: Ministry of Agriculture, Economic Review of Agriculture, January-March, 1975 (Nairobi: Government Printer, 1975).

The general organization of the sugar industry in Kenya is through (i) private ownership and management for the privately owned mills; and (ii) public ownership and contract management for the government owned mills. However, the government has the overall control of the industry and the following ministries are involved at various levels of the running of the industry:

(i) Ministry of Agriculture: cane production and pricing policy;

(ii) Ministry of Commerce and Industry: domestic and foreign trade in sugar;

(iii) Ministry of Lands and Settlement and the Ministry of Co-operative Development: to facilitate and finance small-scale production, either by individuals or by co-operatives, in smallholdings or settlement schemes;

(iv) Ministry of Finance and Planning: overall development strategies and sugar pricing policy;

(v) Office of the President: local administration, which indirectly influences the pace of development and project implementation.

The functioning of a government machinery depends on the actions of different departments, and various Government Ministries are involved in the running of the sugar industry. The various Government departments are expected to plan and work together, toward achieving the production policy goal of self-sufficiency in sugar.

The reliance of sugar mills on their own cane production and the cane deliveries from the outgrowers is summarized in Table 3-3. Except for Ramisi, which relies quite heavily on its own cane production, the sugar mills depend primarily on cane deliveries from the farmers in the zones in which the mills are located.

Cane Yields and Cane-to-Sugar Ratio (CSR)

Yields are normally expressed on a per annum per acre (p.a.p.a.) basis.[1] The highest cane yields obtained so far in the Kenya sugar zones are 65 metric tons p.a.p.a. for the nucleus estates and 15-25 metric tons

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[1] The process of metrication (i.e., switching to the metric system) is not yet complete, particularly in the farming sector, and both imperial and metric measures will be used in the analysis.

TABLE 3-3

Percentage Distribution of Cane Supplies by Type of Producer in 1975

Mill	Nucleus Estate	Outgrowers
Mumias	33	67
Chemilil	20	80
Muhoroni	20	80
Miwani	33	67
Ramisi	75	25

SOURCE: Ministry of Agriculture, Economic Review of Agriculture, January-March, 1975 (Nairobi: Government Printer, 1975).

p.a.p.a. for the outgrowers (predominantly small-scale farmers). At processing, the CSR for the three production zones are:

(i) 12.5-15.0 tons of cane to 1 ton of mill white sugar at Ramisi (Coast Province);

(ii) 10.0-10.5 tons of cane to 1 ton of mill white sugar in the Nyanza Sugar Belt;

(iii) 8.5-9.0 tons of cane to 1 ton of mill white sugar at Mumias (Western Province).

Thus, the national CSR average is 10.9:1, which gives an average of about 9.2 percent sugar content for the cane produced in Kenya. Owing to differences in sugar content for the cane produced in different ecological zones, sugar is, on average, more expensive to produce at the Coast Province, as might be suspected from the above CSR figures. The national average cane yield, for analytical purposes, can be taken as 45 metric tons p.a.p.a. (see Table 3-4).

Cane Production and Alternative Enterprises

Sugar production in Kenya is based on cane as the raw material. Hence an evaluation of potential net cash returns to producers from cane production and alternative enterprises that are possible in the cane-producing zones should be done in order to determine the alternatives that can be considered competitive to cane production as a farm enterprise. This evaluation is important because its results would indicate the alternative enterprises that are likely to affect sugar production adversely.

Cane production in Kenya is almost entirely under rain-fed conditions; only a small amount of cane is supplied to Miwani mill from the Ahero Irrigation Scheme. Although rain falls most of the year in the cane-producing zones, these areas have bi-modal peaks during April-June and October-November periods. Climatic variations have been experienced in the past, when some prolonged dry periods have adversely affected cane and hence sugar production (for example, in 1972, see Tables 5-1 and 5-2 for the cane and sugar production figures).

Cane production is most suitable at elevations of from 1150 metres above sea level. Temperature influences the rate of cane growth so that there is a difference in the length of cane maturation periods between Ramisi at the Coast Province and the other cane producing zones in the country. At Ramisi, the plant crop maturity is reached after 15 months, while ratoon crop takes about 18 months to mature.[1] Therefore, the elevation influences the crop cycle, giving a five year crop cycle of one plant crop and two ratoon crops at the higher elevations (Mumias and Nyanza Sugar Belt); Ramisi can get one plant crop and three ratoon crops during the five year crop cycle.

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[1] After a cane crop matures, the first harvest (or cut) is called the plant crop. After the cane regrows, the consequent harvests (or cuts) are called ratoon crops.

The types of soil on which cane is being grown are known to be deficient in certain nutrients, or to be of low-nutrient levels. Therefore, use of commercial fertilizers is recommended in cane production. Cultivation and tillage practices involve mechanical disc ploughing, harrowing, ridging and inter-row cultivation. Planting and weeding are done manually on most nucleus estates and in all outgrower farms. Small-scale growers who cannot afford to pay for tractors use ox-ploughs for cultivation and tillage. Since harvesting and transportation of cane from the outgrower farms to the mills is fairly demanding, most cane producers have been encouraged to form co-operatives or companies in order to be able to operate a central transportation system. However, a number of outgrowers still handle harvesting and transportation of cane to the mills individually.

The viability of cane and sugar production as a project will depend on the competitiveness of cane production relative to the alternative farm enterprises. A typical farm in the major cane producing zones of Kenya may consist of at least three enterprises comprising cane, maize, and beans/ground-nuts/sunflower/cotton combinations. Typical outgrower farms average between 1 and 6 hectares. Crop combinations are determined by economic as well as social factors such as food requirements, cultural attitudes and customs, and a range of other minor considerations.[1]

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[1] A Synthesis from District and Provincial Annual Reports, Ministry of Agriculture, Nairobi, 1970-1976.

However, one can assume that the farmers' response to economic incentives such as prices and new technologies is generally positive, so that the pattern of farm enterprises will be determined by the inherent desire to maximize profits even under the existing social and cultural constraints.

Under the profit-maximization assumption, the farmers have the opportunity to produce the crop or crop combinations which appear more attractive in terms of net monetary income. Therefore, gross margin and break-even price analyses will indicate the most profitable enterprise for the farmers in any given zone. Based on the District Farm Management Guidelines and the District Annual Reports which the officers of the Ministry of Agriculture prepare for each district in Kenya on an annual basis, Table 3-4 summarizes the major enterprises in the cane-producing zones of Kenya, giving the average maturation periods and yields.

TABLE 3-4

The Major Farm Enterprises in the Cane Zones of Kenya

Enterprise	Maturation Period (Months)	Yield (Metric Tons/ha/Year) Range	Average
Cane	18-22	25-65	45.0
Maize	5-6	3-5	2.7
Beans	2-3	0.4-2.0	1.1
Groundnuts	4-5	0.8-2.5	1.2
Sunflower	4	0.2-2.0	1.1
Cotton	7	0.6-1.5	1.3

SOURCE: District Annual Reports; Provincial Annual Reports; and District Farm Management Guidelines (Ministry of Agriculture, Nairobi) issues for various years, 1970-1976.

Except for cane, sunflower, and cotton which require production in pure stands, typical small-scale farms will normally have mixed cropping enterprises in maize and beans or maize and groundnut combinations. Based on extracts from a confidential report submitted to the Ministry of Agriculture in 1976, Table 3-5 gives the profitability of the various enterprises that are common in the cane producing zones. Table 3-5 indicates that cane production is the most profitable enterprise in the sugar producing zones of Kenya. The dominance of the profitability of cane production can be demonstrated by expressing the net returns from alternative enterprises as a percentage of the returns from cane, as given in Table 3-6.

TABLE 3-5

Profitability of Alternative Enterprises in the Cane Zones of Kenya, 1976 Statistics [Kshs per ha]

Enterprise	Total Cost	Gross Return	Net Return Kshs/ha	Net Return Kshs/Man-day
Sugarcane	976	4545	3249	50.76
Maize/Groundnuts	1255	4343	2218	12.75
Maize/Beans	1025	3246	1481	10.01
Cotton	767	3666	1019	2.71
Sunflower	512	1980	1033	11.87

SOURCE: Ministry of Agriculture, Nairobi (Confidential Report, 1976).

Based on net return calculations, cane production does not appear to face severe competition from any of the existing crops or crop combinations at the given (1976) market prices. The analysis indicates that cane prices could fall by up to 22 percent before cane loses its competitive edge to maize/groundnuts crop combination. Based on the estimated average yield of maize crop, maize is found to be the most competitive enterprise to cane production in sugar producing zones of Kenya.[1]

TABLE 3-6

The Dominance of the Profitability of Cane Production Relative to Alternative Enterprises

Enterprise	Index of Profitability (Percent)
Cane	100.0
Maize/Groundnuts	68.3
Maize/Beans	45.6
Cotton	31.4
Sunflower	31.8

SOURCE: Calculations Based on Figures in Table 3-5.

The payoff of the alternative enterprises was determined above in terms of net cash returns per acre (Table 3-5). The calculation of net returns seeks to estimate the net present value of the benefits accruing to the farmer from each enterprise per unit of land area, or per man-day of labour input. The same information could be established by a technique called break-even price analysis. The break-even price analysis seeks to determine the price at which the enterprise would just pay itself off. At the break-even price, total cost equals total revenue, so that the break-even price can be regarded as the competitive product price. Such price is then compared with the market price.

Calculation of the break-even prices for the various alternative enterprises in the cane (sugar) zones of Kenya indicated that the prevailing (1976) market price for cane was above the competitive price, while the prices of the other enterprises were found to be below the competitive level (see Table 3-7).

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[1] Ministry of Agriculture, Nairobi (Confidential Report, 1976).

TABLE 3-7

Break-Even Price for Alternative Enterprises in the Cane Zones of Kenya [Kshs per ha per annum]

Crop or Crop Combination	Break-Even Price	
	Actual	As % Deviation from the Current Market Price
Cane	78.09	-22.6
Maize/Groundnuts	1525.49	+16.8
Maize/Beans	1221.21	+52.3
Cotton	4741.54	+68.1
Sunflower	4003.63	+122.0

SOURCE: Ministry of Agriculture, Nairobi (Confidential Report, 1976).

At the macro-level, planners are interested in other aspects of an enterprise, besides the profitability aspect. The potential of an enterprise to generate employment in Kenya, particularly in the rural areas, is an important consideration. The labour input requirements by the various alternative enterprises in the sugar producing zones of Kenya are given in Table 3-8.

From the above analyses, cane production is found to be the most profitable enterprise, but it does not generate as much capacity for absorbing the rural unemployed as the alternative enterprises. Given the Government objective of developing agriculture in order to raise and stabilize farm incomes, cane production is an appropriate enterprise to promote in the sugar producing zones of Kenya, since production is possible throughout the year.

TABLE 3-8

Labour Requirements for the Alternative Enterprises in the Cane Zones of Kenya
[No. of Man-days per Ha]

Cane	Maize & Groundnuts	Maize & Beans	Cotton	Sunflower
64	174	148	376	87

SOURCE: Ministry of Agriculture, Nairobi, Kenya (Confidential Report, 1976).

A Synoptic View of the Market for Sugar and the Consumption of Sugar in Kenya

Introduction

Population and disposable income are major determinants of the domestic market for a given commodity. Distribution of the disposable income is an important aspect too, since this determines the effective rather than potential demand for the commodity. The national average population growth rate for Kenya is estimated at 3.5 per annum, although the growth rates have been as high as 7 percent per annum in urban centres.[1] Table 3-9 gives an analysis of the domestic market in Kenya by race, age composition and average annual income per household. The analysis of the domestic market indicates that a large proportion of the population is under the age of 20 years. Since this is the segment of the population that can be expected to join the labour force and probably improve its personal disposable incomes as the economy grows, it appears that the domestic market for sugar is likely to grow in the future. Previous studies indicate that sugar is consumed by a small proportion of

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[1] Government of Kenya, Development Plans, 1970/74 and 1974/78 (Nairobi: Government Printer, 1970 and 1974); and Central Bureau of Statistics, Economic Survey, Various Annual Issues up to 1978 (Nairobi, Ministry of Finance and Planning).

TABLE 3-9

Kenya's Domestic Market by Race, Type, Household Number, Income and Age*: An Estimate

Type of Market and Race	No. of Households (in '000)	No. of Persons per Household	Average Earnings per Household (K£)	Persons Under Age of 20 Yrs. (%)	Expected Annual Change in This Segment
Rural African	1,900	6.0	120	58	+3.2
Urban African	250	4.4	450	44	+8.0
Urban Asian	20	3.0	1,100	41	-6.0
Urban European	9	3.5	2,600	31	-6.0
Tourist**	6				+8.0

*Data based on 1974 population estimate and 1972 income estimate.
**Heterogeneous by race, culture and income.

SOURCE: Gibbons, E.T. "The Characteristics, Structure and Development of Kenya's Food, Feedstuffs and Beverage Industries", Quarterly Journal of International Agriculture, (DLG-Verlag Frankfurt, April-June, 1976), pp. 141-160.

the population; this proportion of population has a relatively high income (Frank, 1964, and others).[1] This observation, and given that the per capita consumption of sugar in Kenya is relatively low (see Table 3-10), suggests that the domestic market for sugar could expand if per capita income rose in the process of economic development. Table 3-10 shows that the per capita consumption of sugar in Kenya is relatively low by world standards so that it can be expected to rise in the future as the nutrition standards of Kenya improve and more people earn a cash income.

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[1] These studies will be discussed under the section on the review of relevant literature.

TABLE 3-10

Per Capita Consumption of Sugar
in Selected Countries, 1972-1973

Selected Country	White Sugar Consumption (kg per capita)
World Average	19.2
Cuba	67.6
U.K.	49.4
U.S.	47.5
U.S.S.R.	40.0
Algeria	19.2
Sudan	16.0
Kenya	15.4
Uganda	17.8
Tanzania	7.8

SOURCE: Adapted from Indian Sugar Annual, July 1973, and as presented in the Confidential Report, Ministry of Agriculture, Nairobi, 1976.

Sugar Consumption and the Sugar Marketing Problem in Kenya

Sugar consumption has been rising very rapidly over the last two decades, from 55,000 metric tons in 1955 to 248,000 metric tons in 1976. The consumption record gives a close fit to an annual growth rate of consumption of 7.5 percent since 1955, although wide variations were experienced during the early 1970s. For instance, the increase in consumption was nearly 14 percent during the 1971/72 period and 11 percent during the 1972/73 period (see Table 5-5). The 1970/74 and 1974/78 Development Plans had anticipated that Kenya would achieve self-sufficiency in sugar by the early or mid-1970s. However, sugar consumption has increased faster while production has been growing less rapidly than anticipated. Kenya thus still continues to import some sugar in order to meet the domestic requirements.

Pricing of both cane and sugar has been controlled and regulated by the Government since sugar was declared a scheduled crop in 1966. Prior to 1966, cane prices used to be in the range of from Kshs 37 to Kshs 48 per metric ton. Since 1966, the Ministry of Agriculture has given a number of Legal Notices (LN) revising the prices of both cane and sugar, primarily to ensure that prices do reflect the rising cost of production and internal demand conditions, while encouraging cane and sugar production at the same time. Tables 5-1 and 5-3 give a summary of the price changes for the period ending in 1976.

All the sugar processed by the mill is sold to the Kenya National Trading Corporation (KNTC), a statutory organization which is empowered to control both the domestic and foreign trade in sugar and is directly answerable to the Minister for Commerce and Industry. To facilitate sugar distribution, the KNTC has a network of 18 depots which are strategically located in the country. The KNTC-appointed distributor-agents buy their sugar from these depots and then stock it in their stores for distribution to retailers. There are well over six hundred such KNTC agents who act as sugar wholesalers in the country.[1] Apart from controlling sugar distribution in the country, KNTC has to plan for and obtain all necessary sugar imports. Figure 3-2 gives a summary of the main marketing channels for sugar in Kenya.

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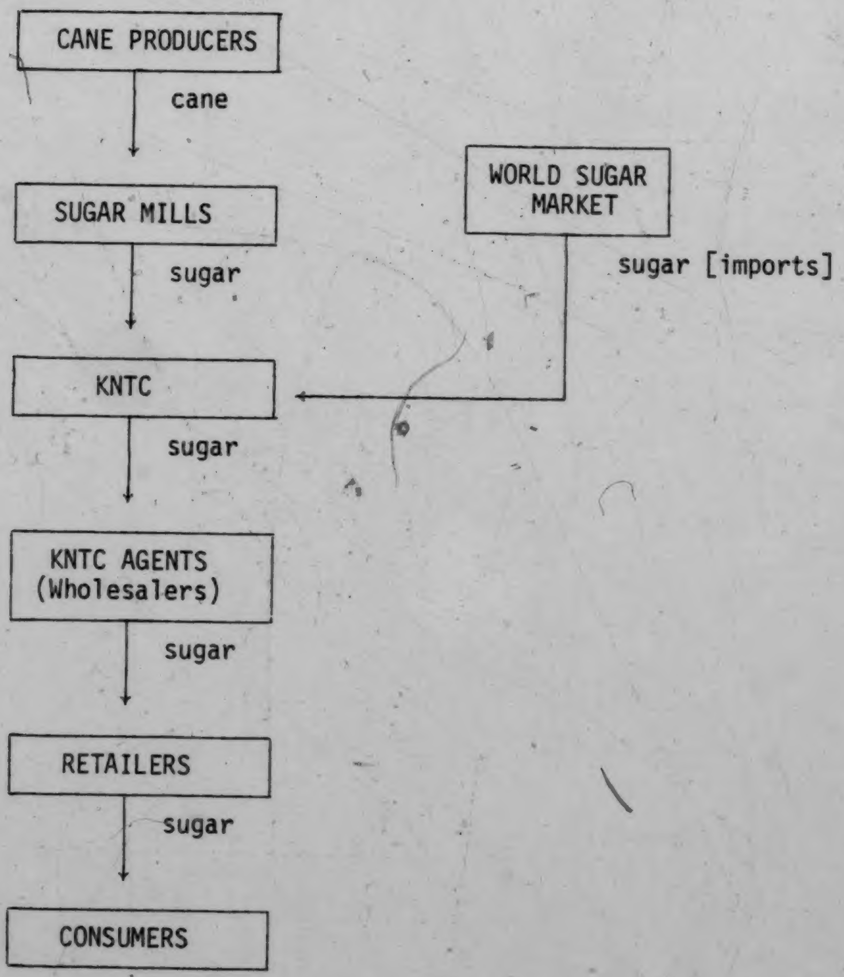
[1] See J. Heyer, J.K. Maitha and W.S. Senga, Agricultural Development in Kenya: An Economic Assessment (Nairobi: Oxford University Press, 1976), p. 336.

FIGURE 3-2

Marketing Channels for Sugar in Kenya


CANE PRODUCERS
cane
SUGAR MILLS
sugar
WORLD SUGAR MARKET
sugar [imports]
KNTC
sugar
KNTC AGENTS (Wholesalers)
sugar
RETAILERS
sugar
CONSUMERS

The arrows indicate the direction of flow, and the type of commodity involved in the flow is given.

Sugar imports are financed by the Sugar and Cereals Finance Corporation, which operates a sugar price stabilization fund. This fund is maintained through a system of pooling in which all sugar in the country is sold at the same price, whether it be the refined imported sugar or the locally produced mill-white sugar. When the sugar imports are cheaper relative to the domestic sugar price, the price stabilization fund is regenerated, while the financing of expensive imports, when the world sugar price is high, depletes the fund. The price of sugar in Kenya includes a small amount of excise duty, which contributes to the price stabilization fund. The price stabilization mechanism is basically a buffer type of operation.

The control of ex-mill and retail prices of sugar by the Government ensures that the marketing margins are controlled. The control of the marketing margins is intended to ensure that the whole country has one retail price of sugar. In a review of the sugar marketing problem in Kenya, Heyer claims that the sugar pricing policy in the past has been a problem because producers have been paid too little, while the consumers have not always paid the full cost of their sugar. This shortcoming in the pricing policy is suspected to have affected the supply of cane to the mills, which has resulted in a great deal of underutilization of mill capacities in the past.[1] One can now say that the trend has been changing drastically, particularly during the 1970s. The Government has continued to revise both cane and sugar prices from time to time in order to ensure that (i) producers are given sufficient incentive to supply the mills with cane; and (ii) consumers meet the cost of their sugar. This has been expected to remedy the cited widespread problem of excess mill capacity. As demonstrated in Table 3-7, the cane producer price in 1976 was too high relative to the break-even (or competitive) price and this has to be taken into account in any recommendation for planning purposes.

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[1] J. Heyer, et. al., op. cit., p. 336.

Concluding Remarks on Production and Consumption of Sugar in Kenya

Both production and consumption of sugar in Kenya have grown relatively fast over the last two decades, but the country has not yet been able to produce all its sugar requirements. However, the percentage of the sugar imports to total sugar consumption in Kenya has been decreasing, and there is an indication that the country could achieve self-sufficiency in sugar supply if the pace of development of sugar production is increased.

Gross margin analysis indicates that cane production gives the highest net return per acre of land, relative to returns from alternative enterprises. Hence farmers can be expected to maintain or even expand cane production and price could be expected to play a major role in regulating cane and sugar production in Kenya. However, maize is the staple food crop, which is also competitive to cane production, and this has to be accounted for in supply response analysis.

The Review of Relevant Literature On the Sugar Industry in Kenya

Introduction

The review of the relevant literature is considered useful in at least two ways. First, the review gives a summary of the market structure, through the synthesis of the findings of the various relevant studies with regard to the structural variables of the sugar industry. Secondly, the review indicates the specific aspects of the sugar industry that require further investigation.

The purpose of this section of the chapter is to stress on those aspects of the various studies that are cited which are considered useful for this study. The review is limited to the literature on the sugar industry in Kenya because the review of literature on sugar industries in other parts of the world was given in the previous chapter.

Literature on Kenya's Sugar Industry

A number of broad-based studies on the feasibility and expansion of sugar production in Kenya have been done for the Government by a number of consultants over the last ten years.[1] As in the case of all Government consultative studies, the results of such studies are not made public. They continue to remain confidential to the Government.

Relatively little is published about the sugar industry in Kenya. The only major studies whose results have been published or presented in a public seminar appear to be those of C.R. Frank (1963 and 1964) and R. Clark (1968).[2] Frank's work was later published in a book in 1964.[3]

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[1] Examples include: (i) Mehta Group Ltd., The South Nyanza Sugar Project: Final Feasibility Report, Phase II Investigations, Vols. I-V, Nairobi 1975; (ii) Bookers' Agricultural Holdings, Mumias Sugar Scheme: Final Feasibility Report, Vols. I-III, Nairobi, July 1976; (iii) Tate and Lyle Technical Services Ltd., and Government of Kenya, Kenya Sugar Industry Expansion Study, Vols. I-IV, Kent, England, 1974; and (iv) Agro-Invest Industrial Consultants and Management Agents, Small Scale Sugar Production in Kenya, Vols. I-IV, Nairobi, 1976.

[2] C.R. Frank, (i) "The Production and Distribution of Sugar in East Africa"; and (ii) "Analysis and Projections of the Demand for Sugar in East Africa", (Unpublished papers presented at the East African Institute of Social Research conferences in 1963 and 1964 respectively, Makerere, Kampala, Uganda); and R. Clark, "Sugar Consumption in Kenya", East African Journal of Rural Development, Vol. 1, No. 1 (1968), pp. 48-51.

[3] C.R. Frank, The Sugar Industry in East Africa: An Analysis of Some Problems and Policy Questions Relating to the Expansion of the Sugar Industry in a Developing Economy (Nairobi: East African Publishing House, 1964).

Frank's main objective was to present a model of a common sugar policy for the three Member States of the then East African Community.[1] In the analysis, Frank used a linear demand model, with the quantities of sugar consumed as the dependent variable and the per capita disposable income and the retail price of sugar as the independent variables. A time trend factor was also incorporated in the model to account for qualitative factors. Under the hypothesis that the governments of the member states of East Africa (i.e., Kenya, Uganda and Tanzania) will always import sugar and sell it at internally fixed prices, supply was taken as price inelastic in the analysis.

The major observations in Frank's study (1964) were that Kenya had persistently been a net importer of sugar and that per capita consumption of sugar in urban areas of East Africa was relatively high, with most of the sugar being consumed by a relatively small and wealthy proportion of the population. Industrial consumption of sugar was found to be relatively low, being only about 5 percent of the total sugar consumption in 1964. The analysis based on the data for the period 1954-1963 showed that the time trend coefficient was significant at the 0.05 level, while the coefficients of the retail sugar price and the per capita disposable income were not significant at that level.

Clark's study (1968) basically used the log-linear version of the demand model used by Frank in 1964. His objective was to make estimates of future sugar consumption levels in East Africa, with special reference to Kenya, based on the assumption of a regular annual percentage increase.

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[1] East African community, which had Kenya, Uganda and Tanzania as Member States, is now defunct, having broken up after persistent disagreements among the Member States in 1977.

He found that income elasticity of demand was high at most income levels, and concluded that the log-linear demand model as specified was unrealistic as a tool for estimating changes in consumption based on changes in sugar price only.

Both the Frank and the Clark studies are now relatively old, since many changes in the political and socio-economic environment in East Africa have occurred since these studies were conducted. However, the analytical models and the comments on planning and policy are still useful as guidelines for further research.

Except for some agronomic and geographic studies, relatively little has been published about Kenya's Sugar Industry since 1968 and prior to 1975. For instance, Acland (1971) gives an account of agronomic aspects of cane production in Kenya, and in East Africa in general. The 1970/74 and 1974/78 Development Plans outline the Government policy objectives, stressing on the importance of the expansion of food production in Kenya. Sugar production is one of the agricultural projects earmarked for expansion.

The following are the latest studies that appear to have focused on economic aspects of the sugar industry in Kenya: (i) two papers released by the Ministry of Agriculture in 1975 and 1977;[1] (ii) a brief synthesis and review of the chief features of the sugar industry by the author of this study in 1977;[2] and (iii) a recent study by M.O. Odhiambo

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[1] Ministry of Agriculture: (i) Economic Review of Agriculture, Vol. 7, No. 1 (Nairobi: Government Printer, 1975); and (ii) "Projections on White Sugar Consumption in Kenya to 1990: Their Reconciliations with Sugar Production and Policy Implications" (Unpublished paper, Nairobi, 1977).

[2] S.G. Mbogoh, "The Structure and Chief Characteristics of Kenya's Sugar Industry," Egerton College Agricultural Bulletin, Vol. 1, No. 2 (Njoro, Kenya, Sept., 1977), pp. 95-101.

(1978) on the structure and performance of the sugar industry, with special emphasis on the Nyanza Sugar Belt.[1] There are also some critical comments, though hardly supported by statistical or empirical evidence, on the problem of sugar marketing in Kenya in an article by Judith Heyer in 1976.[2]

The two papers released by the Ministry of Agriculture focus on two aspects: (i) a general description of the organization of Kenya's sugar industry; and (ii) an analysis of the sugar production and consumption in Kenya, using the time series data to 1976, and employing a linear demand model similar to the one used by Frank in 1964. Projections of supply and demand are made for 1990, in order to assess the sugar situation in Kenya by 1990. Demand projections are based on predictions from the estimated demand functions, but the projections of production are based on *expected* production if the proposed sugar projects are implemented by 1980. Such proposals include establishment of two new sugar mills and the expansion and rehabilitation of the existing sugar schemes. The analyses indicate that the coefficients of the time trend factor and the per capita disposable income are significant at the 0.05 level and that Kenya could become self-sufficient in sugar supply by 1981 if the proposed sugar projects are implemented by 1980. Given the high cost of expansion and the limited resources, the study recommends the use of a pricing policy to regulate demand in order to facilitate an orderly expansion of the sugar industry in Kenya.

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[1] M.O. Odhiambo, *The Structure and Performance of Kenya's Sugar Industry, With Special Emphasis on the Nyanza Sugar Belt* (Unpublished M.Sc. Thesis, Department of Agricultural Economics, University of Nairobi, Kenya, 1978).

[2] The article appears in J. Heyer, J. Maitha and W. Senga, eds. *Agricultural Development in Kenya: An Economic Assessment* (Nairobi: Oxford University Press, 1976).

The study by M.O. Odhiambo (1978) sets out to describe the organization of the sugar industry in Kenya and assess how the existing structure of the industry affects performance at farm, factory and consumer levels. The problems of cane procurement and excess mill capacities are examined. Personal interviews are executed, and the following are the major findings:

(i) Performance is unsatisfactory at the farm, processing, and distribution levels; and

(ii) Shortages of cane supplies to the mills are the main cause of the underutilization of mill capacities. Specifically, cane shortages are attributed to the following factors:

(i) Poor cane husbandry techniques among the majority of outgrower farms, resulting in low yields;

(ii) Poor co-ordination between some mills and their outgrower cane suppliers, coupled with the lack of expert advice and credit facilities for outgrower farmers, thus leading to poor performance; and

(iii) Low cane prices in the past, coupled with low cane yields and rising input prices, which have not been remunerative enough and have tended to discourage further expansion of cane production for some farmers.

M.O. Odhiambo (1978) concludes that the performance of the sugar industry in Kenya is unsatisfactory when judged from the following criteria:[1]

(i) Efficiency of the organization of the industry in terms of plant size, plant capacity utilization, cane procurement and sugar distribution;

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[1] M.O. Odhiambo, op. cit., p. 204.

(ii) Technological progressiveness, both in cane and in sugar production techniques; and

(iii) Profit rates, in terms of the levels that would reward investment, efficiency and innovation.

However, these conclusions are not supported by statistical or quantitative evidence.

After observing that (i) poor extension services to the outgrower farmers are to blame for the persistent poor cane husbandry techniques, and (ii) a number of problems facing the industry could be solved by improving the relations between cane producers and sugar processors, M.O. Odhiambo (1978) reaches the following recommendations:

(i) Provision of extension services to the outgrower farmers should be improved;

(ii) Credit facilities to enable outgrower farmers to purchase essential input services should be provided; and

(iii) There should be a greater co-ordination or integration between cane outgrower farmers and the sugar processors.

As mentioned in the review of literature on the world sugar economy, D. Smith (1976) notes and discusses briefly the various problems that have been examined by M.O. Odhiambo (1978).[1] The adoption of the various recommendations advanced by D. Smith (1976) and M.O. Odhiambo (1978), amongst others, may be expected to lead to improvements in the performance of the sugar industry in Kenya.

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[1] D. Smith's discussion of the sugar industry in Kenya appears in a general survey paper on the sugar industries in Africa, which is presented in the fifth volume of a series of five volumes entitled "Sugar Y Azucar Yearbooks", published by the Sugar Y Azucar Journal in 1976, with D. Smith as the general editor.

Some Comments on Studies Related to the Sugar Industry in Kenya

The publications by the Ministry of Agriculture and the study by M.O. Odhiambo give the latest account of the structure, conduct and performance of the Kenya sugar industry. Like all other previous studies on the sugar industry in Kenya, the latest studies are deficient in a number of respects. These studies have employed the static general linear models in the analyses, thus ignoring the dynamic nature of market relationships over time. No evaluation of the market relationships defined within a simultaneous equations framework appears to have been done. Such shortcomings may have led to the generation of biased results. Another deficiency in the previous studies is the fact that the studies have ignored an evaluation of cane or sugar supply responsiveness to price changes.

There is a need to conduct studies that utilize dynamic models in order to incorporate the effect of time factor in the structural variables of the sugar market. An incorporation of a flexible supply model in the analysis of the market is also considered useful. The fact that the sugar imported is sold at fixed internal prices (Frank, 1964), does not hinder domestic production from responding to price changes. Finally, the existing information on the estimates of the structural variables of the sugar market is relatively old and needs to be evaluated and updated.

The objective of this study is to fill the gaps implied by the deficiencies in the previous studies and contribute to the existing body of knowledge by (i) carrying out the analyses under a dynamic setting (i.e., by using dynamic models); (ii) evaluating the results under the assumptions of both recursive and simultaneous equations systems for the analytic models; (iii) evaluating the responsiveness of supply to price changes; and (iv) updating the results from previous studies. A projections technique will be used in the assessment and evaluation of the current Government self-sufficiency policy for sugar production. The review and discussion of the various analytic models are presented in the next chapter.

CHAPTER IV

THE REVIEW OF THE RELEVANT ECONOMIC THEORY AND METHODS OF ANALYSIS

Introduction

The study sets out to examine and explain the characteristics of the sugar market under a changing socio-economic and political environment in Kenya. An understanding of these characteristics is essential in the formulation of market development and improvement proposals that could serve as policy guidelines to those involved in market planning.

Many factors are likely to interact and influence a given market at any time so that certain postulates are made when analysing a market in order to reduce the range of these factors and the diversity of their influences. This chapter presents a review of (i) the fundamental concepts in economic theory that are relevant to the analysis of supply and demand for a given commodity; and (ii) the relevant methods of analysis.

The Review of the Relevant Economic Theory

Economic theory seeks to explain the behaviour of (i) households, (ii) firms, and (iii) central authorities.[1] From a macro-perspective, economic theory can be regarded as seeking to explain the characteristics of an economy. Conceptually, there are three types of economies: (i) one in which the decisions of individual households and firms exert the primary and major influence over the resource allocation; (ii) one in which the central authorities exert the primary and major influence over resource allocation; and (iii) one in which each of the three groups (viz., households, firms and central authorities) exerts some influence over resource allocation. The first type of economy is called a free market economy, the second type is called a centrally-planned economy, while the third type is called a mixed-market economy and is the prevalent type of economy in the world today.[1] The author would prefer to call the third type a regulated market economy.

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[1] R.G. Lipsey and P.O. Steiner, Economics (New York: Harper & Row Publishers, 2nd edition, 1969), pp. 72-73.

An economic decision may involve planning for either production, sales or purchases. Prices have a major influence in determining such a decision, particularly in free-market and, to some extent, regulated market economies, since they act as the major signal to where resources should be allocated. Hence, studies related to market analysis should give some emphasis to price analysis, which primarily focuses on supply and demand analysis. The sugar market in Kenya fits the model of a regulated market economy so that price analysis will be a major component in the analysis of the industry.

Details of the basic postulates of (i) firm and industry supply curves, and (ii) consumer behaviour that results in market demand curves can be found in most textbooks on microeconomic theory.[2] The purpose of this section on the review of economic theory is to present a brief account of some concepts that are useful in supply and demand analyses before focusing on a detailed discussion of supply and demand functions.

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[1] Ibid.

[2] Examples of such textbooks include (i) R.G. Lipsey and P.O. Steiner, Ibid.; (ii) J.M. Henderson and R.E. Quandt, Microeconomic Theory: A Mathematical Approach (New York: McGraw-Hill, Inc., 1971); (iii) H.L. Varian, Microeconomic Analysis (New York: W.W. Norton & Company, Inc., 1978); and (iv) H.A.J. Green, Consumer Theory (London: Macmillan Press Ltd., 1976). Among the books cited, H.L. Varian gives the most concise treatment of the microeconomic theory.

Theory of Supply and the Supply Function

The theory of supply is technically a theory of production. Production consists of transforming inputs into outputs. This technical relationship between output and the factors of production is expressed mathematically in a production function, which is defined only for non-negative values of the input and output levels. The selection of the optimal input combination for the production of a particular output level, or the selection of output combinations, depends on input and output prices and is the subject of economic analysis.[1]

A basic postulate in the theory of supply is the notion that producers make consistent decisions in relation to the choices open to them, the basic motivation being the desire to maximize profits. Profit maximization as the basic motivational hypothesis in the theory of production has recently come under serious attack. A number of competing hypotheses, such as revenue and sales maximization, growth maximization, and some other managerial discretion theories, have been offered.[2] Without passing judgment on the superiority of any of the competing motivational hypotheses in the production theory, the profit-maximization hypothesis is considered a useful hypothetical premise in the analysis of supply responses as proposed in this study.

Producers use the services of the inputs in the production of output. These services must be paid for. Such payments constitute production costs. There are two types of inputs: (i) fixed inputs; and (ii) variable inputs. Costs associated with fixed inputs are called fixed costs, and these costs must be paid, regardless of whether the firm produces at all. Costs associated with variable inputs are called variable costs: these costs are incurred only if production takes place and are a function of the level of output. The total production cost is the sum of fixed and variable costs.

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[1] J.M. Henderson and R.E. Quandt, op. cit., pp. 52-55.

[2] See, for example, W. Nicholson, Microeconomic Theory: Basic Principles and Extensions (Hinsdale: The Dryden Press, Inc., 1972), pp. 181-191; and J.V. Koch, Industrial Organization and Prices (Englewood Cliffs, N.J.; Prentice-Hall, Inc., 1974), pp. 29-48.

Profit is defined as the difference between total revenue and total production cost, where total revenue is given by the product of the total quantity supplied and sold and the price of the commodity concerned. Under the profit-maximization hypothesis, producers are expected to vary the levels of output to ensure that the cost levels are consistent with profit-maximization. Two conditions are necessary and sufficient for profit-maximization: (i) a given input must be utilized up to a point at which the value of the marginal product of the input equals its price; and (ii) profit must be shown to decrease with respect to further application of the given input after the point of equality between the input price and the value of marginal product is exceeded.

The above conditions of profit-maximization will hold under the assumptions of both fixed and varying prices regardless of the number of inputs and outputs involved in the production process. Under all conditions, the profit-maximization hypothesis implies that producers are expected to adjust their production decisions in order to maximize profits at any given price and output combination levels.[1] Output combinations can thus expected to be based on a consideration of relative profitabilities of the alternative enterprises. Therefore, one can examine the response of producers to changes in price levels under the hypothesis that producer behaviour is motivated by the desire to maximize profits.

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[1] J.M. Henderson and R.E. Quandt, op. cit., pp. 56-97.

Input and output levels are rates of flow per unit of time. The period for which these flows are defined determines whether one is considering a short-run or long-run production function. For a short-run production function, the period for which the flows are defined must be: (i) sufficiently short so that the producer cannot alter the levels of the fixed inputs; (ii) sufficiently short so that no technological changes occur; and (iii) sufficiently long to allow for the completion of the necessary production process.[1] In the long run, all inputs are assumed to be variable, and the analysis can be shifted to a long-run basis by relaxing condition (i) above and defining the production function for a period long enough so that all inputs are taken as variable. These concepts are important in supply analysis, and are applicable in the determination of short-run and long-run supply functions.

A supply function can be defined as a mathematical expression of the relationship between the quantity of a commodity that is supplied and the factors that influence its supply. Empirical determination of the supply function for sugar in Kenya is one of the main objectives of this study.

Estimation of Supply Functions

The supply function for a specified commodity could be estimated either for an individual firm (to obtain an individual supply function) or for the industry (to obtain an aggregate supply function). The aggregate supply function is mathematically a summation of the individual supply functions for all the firms in the given industry.

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[1] J.M. Henderson and R.E. Quandt, op. cit., p. 55.

Supply functions could be derived through a production-function route. This approach would involve: (i) an empirical determination of the production function; (ii) calculation of the input and output combinations that are consistent with the empirical production function; (iii) calculation of average fixed and variable costs that are associated with the various output levels, and (iv) derivation of the supply functions from the cost curves obtained by using the data generated in step (iii) of the analysis.

The derivation of average fixed and variable costs that are consistent with output levels given by the empirical production function enables the analyst to obtain data from which to plot average total cost curve (ATC), average fixed cost curve (AFC), average variable cost curve (AVC) and marginal cost curve (MC). Marginal cost is the additional cost of production that is incurred by further application of a unit of the variable inputs. Theoretically, one can derive the marginal cost function from the total cost function. In practice, there are difficulties in determining an empirical marginal cost curve.[1]

After having determined the cost functions, one derives the short-run supply function as the segment of the marginal cost curve that is above the average variable cost curve. In the long run, all total costs must be covered for a production process to be economically viable so that the long-run supply function can be conceptualized as the segment of the marginal cost curve that is above the average total cost curve. Figure 4-1 gives the various average cost curves and the implied supply functions.

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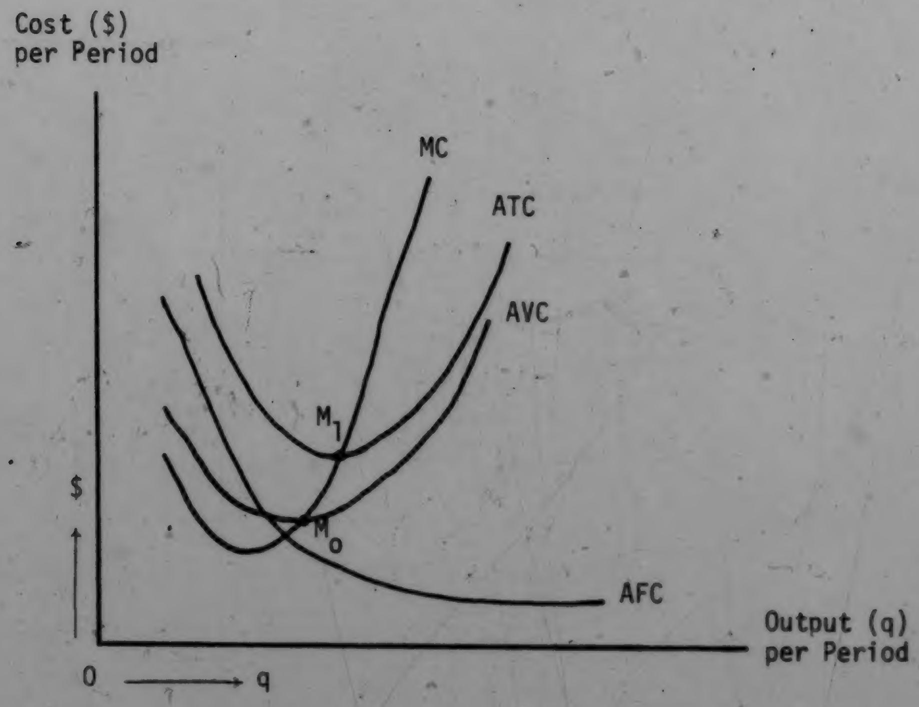
[1] For a detailed discussion of the derivation and properties of cost functions, see J.M. Henderson and R.E. Quandt, op. cit., pp. 70-79.

FIGURE 4-1

Average Cost Curves and Derived Supply Functions[1]



Empirically determined production function would be a useful policy guide because such a function would give a description of the actual rather than the theoretical physical relationship between inputs and output. The empirical production function would also enhance one's knowledge or understanding of the basic production system, thus facilitating the discovery of means to control output levels when necessary. This knowledge would further be enhanced through the derivation of supply functions from the empirical production function when necessary. However, there are inherent difficulties in fitting production functions and deriving supply functions from such fitted production functions for agriculture, especially at the macro level.

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[1] Notes to Figure 4-1:
(i) M_o = minimum of AVC
(ii) M_1 = minimum of ATC
Conceptually:
(iii) Short-run Supply Function = MC above M_o
(iv) Long-run Supply Function = MC above M_1

Empirical determination of production functions in agriculture, particularly at the macro level, is hampered by the problem of measurement and aggregation of inputs. This problem has led economists to adopt the use of directly determined supply functions, rather than empirically determined production functions, as policy guides for agricultural production.[1] The problem of measurement could be minimized if proper and standardized input records for farms were kept, but a complete elimination of the aggregation bias would be difficult to achieve for agricultural production.

Given the problems encountered in empirical determination of production functions and when deriving supply functions through the production-function route, particularly in relation to derivation of average cost curves, one can understand why the direct estimation of the supply functions for agricultural products has become the conventional approach to the generation of data for production policy guidelines. Direct estimation of the supply function involves the specification of quantities supplied as a function of the factors that influence the level of supply followed by econometric estimation of the implied supply-estimating model. The supply relationship may be estimated for an individual firm or the industry, but the researchers are often interested in the aggregate (industry) relationship, which is the aspect of interest in this study.

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[1] V.W. Yorgason and D.E. Spears, "The Canadian Agricultural Production Function," Canadian Journal of Agricultural Economics, Vol. 19, No. 1 (July 1971), pp. 66-76.

If Q^s_{it} is the total quantity of the ith product that is supplied by a given industry during a specified time period t, several factors are likely to influence the observed level of supply. For analytical purposes, only the major influencing factors are considered. The various influencing factors can be classified into: (i) the price of the given product (P_i); (ii) the prices of competitive products (P_j); (iii) the prices of complementary products (P_k); (iv) the prices of the inputs (P_r); (v) the state of technology (T); and (vi) other exogenous factors (V), such as weather or the political and socio-economic environment. The aggregate function of the i^{th} product can then be expressed as:

$$Q^s_{it} = F(P_i, P_k, P_r, T, V) \qquad (4\text{-}1)$$

with the expectations that $F_i > 0$; $F_j < 0$; $F_k > 0$; $F_r < 0$; and $F_T > 0$, where the subscripted F notations are the partial derivatives with respect to the appropriate factors at the specified time period, and F in the formula gives the functional relationship.

The partial derivatives give the expected effects of the appropriate factors on the supply of the given product. For instance, $F_i > 0$ implies that the quantity supplied is expected to increase when the price of the given product rises, while $F_j < 0$ implies that the quantity supplied is expected to decrease as the prices of competitive products increase. No specific expectations are assigned to V (= other factors, such as policy and weather) a priori: this issue is subject to empirical determination.

Several alternatives of production may be open to producers at any time. Production of some commodities may involve either competitive, supplementary or complementary product-product relationships.[1] These terms refer to the degree of competition for available resources in the production of different commodities. Two products are competitive if the output of one can be increased only through the decrease in the output of the other. If two products are complementary, then the output of the two products can be increased at the same time, without making any sacrifices in the level of any output. Supplementary products can be regarded as a special case of complementarity: two products are supplementary if, for a given level of resources, the output of one product can be increased without affecting the level of the other output.

The product-product relationships will normally vary depending on the levels of output, but the common situation is where the products compete for the available resources and are therefore said to be competitive. The effect of the prices of other commodities on the supply of a given commodity will thus depend on the type of relationship between these commodities and the given commodity. The effect is negative in the case of competitive relationship and positive in the case of complementary relationship. Hence, it is important to know the relationships existing among crops that can be produced in a given region when analysing crop supply responses. This relationship is competitive in the case of sugar production in Kenya.

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[1] For a detailed discussion of product-product relationships, see E.O. Heady, Economics of Agricultural Production and Resource Use (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1961), pp. 217-233.

Technology affects supply through its effect on productivity. Improved production methods lower production costs and increase the profitability of a given enterprise and are thus likely to result in a shift in the supply curve. The time trend variable has been used in supply response analysis mainly to account for systematic changes over time which are not accounted for by any other variable in the estimating model. The estimated coefficient of the time variable is then interpreted as a measure of autonomous changes which are expected to affect only the intercept term of the estimating model, leaving the structural coefficients of the model unaffected. Consequently, a time variable will also account for changes in technology and other qualitative factors over time.

Finally, the political and socio-economic environment may be expected to influence the supply of a given commodity. The major variable to be considered is the government policy. The systematic effects of the changing political and socio-economic environment will normally be reflected by the coefficient of the time variable, but one may introduce the effects of major policy changes in the estimating model through the use of a dummy variable. The use of dummy variables presupposes that only the intercept term of the model changes and that the structural coefficients of the model remain constant over time, a presumption that is also made when using the time trend variable.

As presented in equation (4-1), the specification of the supply function is based on the assumption that the producers will respond spontaneously to changes in the factors which influence supply, by adjusting their production levels so that the quantities implied by the model are supplied. In the case of agricultural production, there is usually a long time lag, from the time the decision to produce is made to the time the output is ready for the market. The time lag depends mainly on the maturation period of the agricultural product concerned. Hence, the supply function given by equation (4-1) has to be modified in various ways in the analysis of sugar supply response. Such modifications will be demonstrated in a later section of the chapter.

Measurement of Supply

The relation of supply to each of the variables upon which it depends can be studied by analysing the supply response to changes in a given variable while holding each of the others constant (the ceteris paribus principle). Since the main objective of studying the relation of supply to the variables upon which it depends is normally to get some information which can be used when planning either for production or for the improvement of the market for a commodity, the most important variable is the price of the commodity.

A supply schedule refers to a table which summarizes the quantities of a commodity the producers are willing to sell at different prices for the commodity. When this information is plotted on a graph, a supply curve is obtained. The quantity of a commodity supplied increases as its price increases, and this relationship is illustrated by an upward-sloping curve. The supply curve shifts to the right (an increase in supply) if the prices of other commodities fall, or if the costs of producing the commodity fall, or if producers become, for any reason, more willing to produce the commodity. Opposite changes shift the supply curve to the left (a decrease in supply).

Elasticity of supply of a commodity is defined as the percentage change in quantity supplied resulting from a percentage change in the price of the commodity, and is thus a measure of the degree to which the quantity supplied responds to price changes. By taking infinitesimal changes in quantities and prices, one gets the point elasticity of supply, which is the concept of elasticity that is used in theoretical discussions and is mathematically given as:

$$^{\eta}(pes) = \frac{PdQ}{QdP}$$

where dQ/dP is the derivative of quantity supplied with respect to price at a point on the supply curve, P and Q are the corresponding price and quantity at that point, and $^{\eta}(pes)$ is the price elasticity of supply.

Elasticity of supply is an important measure of producers' response to changes in economic incentives such as price. The elasticity depends largely on how costs behave as output is varied: if costs of production rise rapidly as output rises, then the stimulus to expand production in response to a price rise will be low, and the implied supply function will be price inelastic. Conversely, if costs only rise slowly as production increases, a price rise is likely to result in a large increase in the quantities supplied, and the implied supply function will be elastic with respect to prices.

Theory of Demand and Demand Functions

The theory of demand is often called the theory of consumer behaviour. The amount of commodity which consumers desire to purchase, at a given state of all the factors that influence their willingness to make these purchases, is called the quantity demanded of that commodity. The quantity demanded is thus a desired quantity and is not necessarily the quantity that the consumers actually succeed in purchasing. Since the desired quantities are unobservable, a basic assumption in empirical demand analysis is the notion that the actual purchases are a true reflection of the desired quantities. For this reason, empirical determination of demand functions is based on actual purchases.

The basic motivational hypothesis in the theory of demand is the assumption that consumers desire to maximize utility from the commodities they plan to buy subject to their income constraint. Utility is conceptually the satisfaction which a consumer derives from the possession of a given commodity.[1] A consumer is said to possess a utility function that can be maximized if certain basic axioms are satisfied. These axioms comprise (i) comparability (completeness); (ii) transitivity; (iii) rationality in selection; (iv) monotonicity (non-saturation); (v) continuity of preferences; (vi) strict convexity; and (vii) smoothness of indifference curves.[2]

The actions of a consumer are said to be rational and consistent if none of the axioms given above are violated. If axioms (i) through (iv) are satisfied, then a consumer is said to exhibit downward-sloping indifference curves. If axioms (v) through (vii) are satisfied, then, for any pair of commodities q_i and q_j, and given the quantities of all other commodities, the marginal rate of substitution (MRS) of q_j for q_i is a continuous and decreasing function of q_i.[3]

If the consumer behaves rationally and consistently so that a utility function for this consumer does exist, and if this consumer has a selection of the commodities $q_1, q_2, \ldots, q_n$ available to him for purchasing at prices $p_1, p_2, \ldots, p_n$ respectively, then the utility-maximization conditions require that the consumer equates the ratio of marginal utilities to the ratio of prices for any pair of commodities. At the utility-maximization level, the marginal rate of substitution (MRS) must be equal to the ratio of the marginal utilities along any indifference curve, where MRS is the rate at which one commodity must substitute another in order to maintain the same utility level.[1] An indifference curve defines the locus of commodity bundles (i.e., commodity combinations) that yield the same level of utility to a consumer.

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[1] The terms output, product and commodity are synonymous and are used interchangeably in the theory of supply and demand.

[2] For a detailed discussion of the axioms and the associated concepts, see, for example, H.A.J. Green, op. cit., pp. 21-44.

[3] Ibid., p. 34 and p. 43.

The equality of MRS and the price ratio is a necessary condition for utility maximization. The assumption of strictly convex indifference curves guarantees that the second-order (or sufficient) conditions for a maximum are satisfied.[2] If one considers the utility-maximization conditions, one can conclude that, given the level of consumers' income, the price of a commodity is a major determinant of the demand for the given commodity.

The quantity demanded of a commodity depends on the consumer tastes or preferences, the price of the commodity, the prices of other commodities, the size of the population and the distribution of income. Tastes are not quantifiable and are often taken as given when carrying out economic analysis. However, it is known that when tastes change, for whatever reason, there are increases in the quantities of some commodities that are demanded and decreases in the quantities of others. The higher the price, the lower the quantity of the commodity that is expected to be demanded. The relevant aspect of a price change in demand analysis is that the price changes in relation to the prices of other commodities. For example, a price change would have a greater impact on demand if the price of the given commodity changed while the prices of other commodities remained constant, or if the price of the commodity remained constant while the other prices changed.

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[1] MRS is sometimes referred to simply as the rate of commodity substitution (RCS).

[2] For example, see J.M. Henderson and R.E. Quandt, op. cit., pp. 14-19 for a discussion of the derivation of the utility-maximization conditions.

Commodities can be either substitutes or complements. If two commodities are substitutes, then one can be used to satisfy the same needs as the other, and the consumer would be expected to buy the cheaper one. If two commodities are complements, they tend to be used together. The expected effects of price changes are that: (i) a decrease in the price of a substitute will lead to a decrease in the demand for the original commodity; and (ii) a fall in the price of a complement will lead to an increase in the demand for the original commodity.

The demand function for a specified commodity can be defined as the mathematical expression for the relationship between the quantity demanded and the factors which influence demand. If the expression gives the relationship in terms of the quantities demanded by an individual consumer, the relationship is referred to as an individual demand function. If the expression is given in terms of the quantities demanded by all the consumers, the relationship is referred to as an aggregate demand function. The two types of relationships are related in that the aggregate demand function is mathematically a summation of all the individual demand functions for a given commodity.

A general demand relationship can be expressed as:

$$Q_t^d = f(P_i, P_c, P_s, Y, T) \qquad (4\text{-}2)$$

with the expectations that $f_i < 0$; $f_c < 0$; $f_Y > 0$; $f_T > 0$; and $f_s > 0$;

where Q_t^d = quantity demanded

P_i = price of the commodity

P_c = price of complements

P_s = price of substitutes

Y = disposable income

T = time variable (a trend factor)

The subscripted f notations are the partial derivatives of quantity demanded with respect to the appropriate variables. These partial derivatives give the signs of expected effects of the various variables on the level of demand. As implied in the preceding paragraph, equation (4-2) either defines an individual demand function if variable Q_t^d is the quantity demanded by an individual consumer and the variable Y is the per capita disposable income, or an aggregate demand function if Q_t^d is the total quantity demanded by all consumers and Y is the total disposable income (for all consumers). Equation (4-2) includes a time trend factor as an explanatory variable. The time trend variable is introduced in order to account for autonomous changes or other qualitative factors not accounted for by any other variable in the model. For instance, changes in tastes cannot be quantified and the time variable will account for such changes, if any.

In order to facilitate the analysis of the effect of each variable on the quantities of a commodity that are demanded, each variable is allowed to change while holding all the other variables constant and the resulting changes in the quantities demanded are observed. In demand analysis, the main interest lies in the examination of the effects of changes in prices and income on the quantities demanded.

Changes in the price of the given commodity, as well as changes in the prices of all other commodities, will influence the level of demand for the given commodity. The actual effect of the changes in the prices of all other commodities will depend on whether these other commodities are substitutes or complements relative to the given commodity. There are cases where commodities are neither close substitutes nor complements, so that the demand for one commodity is expected to remain unchanged when the prices of the other commodities change. The demand schedule gives in a tabular form the quantity demanded of a commodity at different prices, holding all the other factors which influence the demand constant. When the data from a demand schedule is plotted in a graph, a demand curve, which is downward-sloping, is obtained. The demand relationships are developed and discussed further in later sections of the chapter.

Measurement of Demand

The responsiveness of quantities of specified commodities or goods[1] which are demanded to changes in the variables upon which demand depends is measured by demand elasticities.

The price elasticity of demand is defined as the percentage change in quantity demanded resulting from a percentage change in price of the commodity: this concept can be expressed mathematically as:

$$^{\eta}(ped) = -\left(\frac{PdQ}{QdP}\right)$$

where $^{\eta}(ped)$ is the price elasticity of demand for the given commodity, dQ/dP is the derivative of quantity demanded with respect to price at a particular point on the demand curve, and P and Q are the price and quantity levels at that point. From the theoretical reasoning that the quantity demanded should decrease as price increases, or increase as price falls, the expression dQ/dP will give a negative value, and the negative sign must be inserted in the definitional formula in order to get positive values for the price elasticity of demand. Other measures of responsiveness of quantities demanded to changes in economic variables include income and cross-price elasticities.

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[1] The terms commodities and goods are synonymous and are used interchangeably in demand analysis, although the latter term is used more frequently.

Income elasticity of demand measures the percentage change in the quantity demanded resulting from a percentage change in income, and can be expressed mathematically as:

$$^{\eta}(yed) = \frac{YdQ}{QdY}$$

where dQ/dY is the derivative of quantity demanded with respect to income, Y and Q are the corresponding income and commodity levels, and $^{\eta}(yed)$ is the income elasticity of demand. Goods can be categorized into two broad classes, depending on consumption behaviour with respect to changes in income: these classes are (i) normal goods, and (ii) inferior goods. For normal goods, increases in income lead to increases in quantities demanded so that income elasticity will be positive. For inferior goods, an increase in income leads consumers to demand less of the commodity and income elasticity will be negative. However, there may be some situations where individual and/or aggregate demand schedules may be unaffected by the level of income, so that the income elasticity is zero. An example may be a situation where the consumers have relatively high income levels.

The responsiveness of demand for a given commodity to changes in the price of another commodity is called cross-price elasticity of demand and is expressed mathematically as:

$$\eta_{(ced)} = \frac{P_j dQ_i}{Q_i dP_j}$$

where $\eta_{(ced)}$ is the cross-price elasticity of demand for i^{th} good with respect to j^{th} good, dQ_i/dP_j is the derivative of the quantity of the i^{th} commodity that is demanded with respect to the price of the j^{th} commodity, and P_j and Q_i are the corresponding price and commodity levels. Goods can be classified either as complements or as substitutes, the two broad classes being based on how the quantities of a given commodity that are demanded change as prices of other commodities change. Complementary goods, such as sugar and tea (as a beverage), will have negative cross-price elasticities while substitute goods, such as coffee and tea (as beverages) will have positive cross-price elasticities. The closer the relation of substitutability or complementarity between goods, the larger the quantity reaction for a given price change. If any two goods bear little relation to each other, one expects their cross-price elasticities to be close to zero. Generally, the price elasticity of demand depends on the degree of availability of close substitutes. Commodities having close substitutes will exhibit relatively high price elasticities of demand.

Some Further Reflections on the Concept of Elasticities

As presented in the separate subsections on the measurements of supply and demand, the concepts of elasticity are normally discussed either in terms of arc elasticities or point elasticities.[1] Arc elasticity

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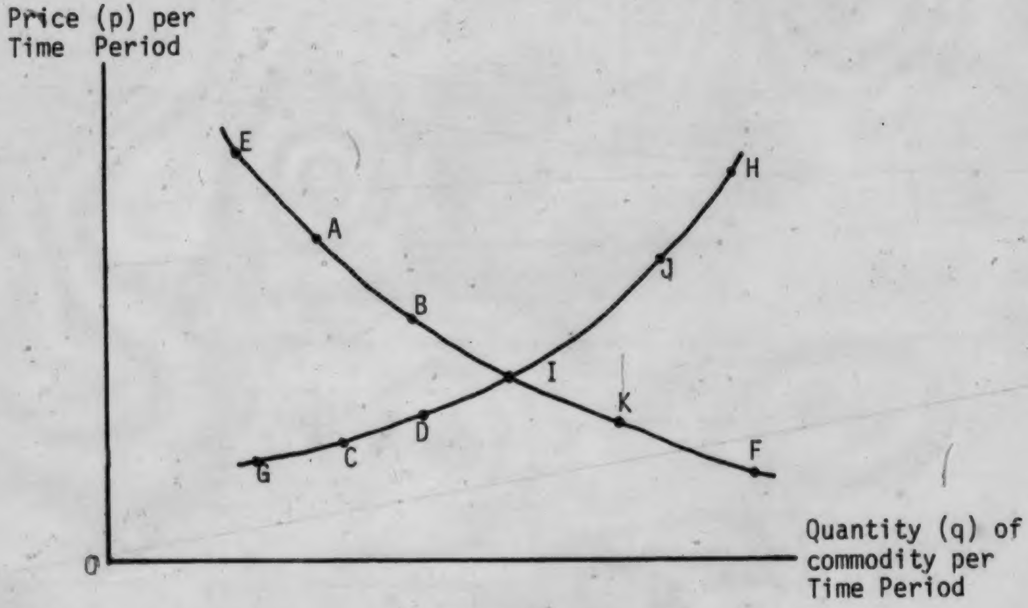
[1] See, for instance, W.J. Baumol, Economic Theory and Operations Analysis, 4th edition (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1977), pp. 183-190.

is a measure of average responsiveness to price changes exhibited by the supply or demand curve over some finite segment of the curve, such as AB or CD in Figure 4-2. Hence the arc elasticity concept involves use of finite ranges of variables. Point elasticity is then the corresponding concept when the responsiveness is considered for each particular point on the supply or demand curve, for instance at point A, B, C, or D in Figure 4-2.

FIGURE 4-2

Measurement of Supply and Demand Elasticities


Price (p) per Time Period
E
A
B
I
K
F
H
J
D
C
G
0
Quantity (q) of commodity per Time Period

Point elasticity is determined by taking partial derivatives at the appropriate points in order to obtain proportionate changes in quantities and prices. Hence point elasticity may be taken as the limit of the arc elasticity value as the finite segment (arc) considered (e.g., AB or CD) is made infinitesimal. Except for a few special cases whereby a curve or a straight line exhibits a constant elasticity over its entire segment, the common situation is one in which elasticity changes as one moves along a given segment of a straight line or a curve. The preceding considerations give rise to the following properties for the measures of elasticity:[1]

(i) Given any segment of the demand curve, a change in price within that curve will have no effect on the product of price (p) and the quantity demanded if and only if the elasticity of demand throughout the range is exactly equal to unity;

(ii) If a demand curve is inelastic (i.e., if the curve has an elasticity less than unity), a rise in price will raise consumer expenditure (pq) and vice versa;

(iii) If the demand curve has an elasticity greater than unity (i.e., if the curve is elastic), a fall in price will raise consumer expenditure and vice versa.

An omission that one often finds in the discussion of elasticities is the question of what happens to the values of elasticities at very low and very high general levels of the economic variables such as price and income relative to the supply or demand for a specified commodity. A general postulate that is often made is the notion that the price elasticity of demand approaches zero as the point of intersection between the demand curve and the horizontal axis is approached and that this elasticity approaches infinity as the point of intersection between the demand curve and the vertical axis is approached. Similar postulates hold if the supply curve intersects with the horizontal or vertical axis. These postulates could be confirmed or tested in empirical analysis. Some studies have shown that the length of time period over which observations on price and quantity changes are made will influence the value of estimated elasticities.[1] An analysis of elasticities could thus examine the influence of time on calculated elasticity measures.

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[1] See W.J. Baumol, op. cit., pp. 188-189; note that the properties are more applicable to demand curves since supply curves are unlikely to be hyperbolic and unitary elastic from theoretical considerations.

This study will examine the range of elasticities at low and high price levels, and attempt to assess the effect of time on the calculated elasticity measures. Referring to Figure 4-2, empirical estimates of elasticities at points like E and F on the demand curve and G and H on the supply curve will be made, thus facilitating the establishment of the confidence interval or the range for the estimated elasticity measures. This is a concept which appears to be useful in empirical studies, such as this one, though it has rarely been discussed or evaluated in empirical supply and demand analysis.

The Review of the Methods of Analysis

Introduction

This section of the chapter focuses on the methods that are used in supply and demand analysis and the related literature. Such literature is extensive, but the basic concepts covered in such literature are similar and can be isolated. The objective of this review is to present such concepts, emphasizing those aspects that are considered more relevant to this study.

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[1] See, for example, W.G. Tomek and K.L. Robinson, "Agricultural Price Analysis and Outlook," in L.R. Martin, ed., A Survey of Agricultural Economics Literature, Vol. 1 (University of Minnesota Press, 1977), pp. 329-409.

An Overview on Empirical Demand and Supply Analysis

The classical model of demand and supply analysis is attributed to Alfred Marshall,[1] and may be discerned in his famous works. In the Marshallian model, price is assumed to be the major factor that influences the quantities of a given commodity that are demanded and supplied, since income is held constant. A common representation of the demand and supply relationships in the Marshallian model is:

$$\left.\begin{array}{ll}\text{(i)} & \text{Demand function: } Q^d = a_0 + a_1 P \\ \text{(ii)} & \text{Supply function: } Q^s = b_0 + b_1 P\end{array}\right] \qquad (4\text{-}3)$$

where Q^d = quantity demanded;
Q^s = quantity supplied;
P = price of the commodity;

and a_0, a_1, b_0, and b_1 are the underlying structural coefficients (parameters) of the models. Economic theory gives various reasons why a_1 and b_1 should be expected to be negative and positive respectively. No expectations on the signs of a_0 and b_0 can be imposed *a priori*. The theory also asserts that Q^d and Q^s are determined simultaneously in the market. Hence a complete study of a market should include an analysis of the process whereby buyers and sellers arrive at a price $\bar{P}$ that equates Q^d and Q^s.[2]

Various theoretical descriptions have been put forward to explain how $\bar{P}$ could be attained. A common hypothesis in the theory of price formation is the idea that the equilibrium price results from an auctioneering type of process. The theory assumes that either function (i.e., Q^d or Q^s) operates alternatingly as if buyers and sellers announce in turn what prices they set or what quantities they are willing to trade. The result is an iterative process which, under certain conditions, will converge to the equilibrium price $\bar{P}$ so that the market is cleared, with the quantity $\bar{Q}$ being traded.

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[1] A. Marshall, *Principles of Economics* (London: Macmillan and Company, 1920); see A.C. Chiang, *Fundamental Methods of Mathematical Economics* (New York: McGraw-Hill, Inc., 1967), pp. 428-430. Note that Marshall's book was first published in 1890.

[2] See A.C. Chiang, *op. cit.*; and C.F. Christ, *Econometric Models and Methods* (New York: John Wiley & Sons, Inc., 1966).

The equilibrium price and quantity $(\bar{P},\bar{Q})$ represent the point of intersection of the demand and supply functions. If shifts occur in either function, or in both functions, for whatever reason, there will be variations of the equilibrium price and quantity. Such shifts are likely to occur over time and can be induced by variables other than price that influence the level of supply and demand schedules. Hence a dynamic theory is important in the analysis of a market over time. A dynamic theory is one into which time enters in such a way that changes can occur in the variables of a model even though the structure of the model does not change.[1] Empirical analysis employs either recursive equations systems in which price and quantity are assumed to be determined sequentially or simultaneous equations systems in which price and quantity are assumed to be determined instantaneously.

If shifts in the functions occur, adjustments to new conditions may take some time to work out. In empirical studies, variables other than price that influence demand and supply schedules have to be accounted for in the model in order to allow for variations in the equilibrium price and quantity. This is usually achieved by summarizing the effects of minor variables in the stochastic variable and by incorporating the major variables in the model.[1] Under such conditions, equation (4-3) can be modified and rewritten as:

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[1] C.F. Christ, op. cit., p. 31.

$$\begin{aligned} &\text{(i) Demand function: } Q_t^d = a_o + a_1P_t + U_t \\ &\text{(ii) Supply function: } Q_t^s = b_o + b_1P_t + V_t \end{aligned} \qquad (4\text{-}4)$$

where the stochastic variables U_t and V_t are used to represent the effects of all other factors, other than price, that influence the demand and supply schedules and the t-subscripts denote observations at a specified time period.

The demand and supply functions as specified in model (4-4) form the basis of the models used in empirical demand and supply analysis. In the analysis of the sugar industry in Kenya, various modifications to the equations given in model (4-4) are needed, as will be described in later sections of the chapter. The determination of the functions within a simultaneous equations framework is likely to improve the reliability of estimated coefficients. Hence both the demand and supply functions will be estimated first as single equation models and then as simultaneous equations model in order to compare and assess the results. The procedures involved, including the derivation of the models, are discussed in a later section.

If a market is not in equilibrium initially, the adjustment process, given sufficient time, may lead to equilibrium. In the absence of market intervention, particularly from central authorities, price changes are governed by relative strength of supply and demand forces. Where central authorities participate in market decisions, particularly in price regulation, their role may be likened either to that of an auctioneer, if prices are regulated with due consideration of supply and demand forces,[1] or to that of intervention if their actions hinder normal market adjustment processes.

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[1] A.C. Chiang, op. cit., pp. 428-430.

From the above considerations, regulated markets, such as the sugar industry in Kenya, may take a long time to achieve the equilibrium price and quantity. Parametric studies of production and consumption of sugar in Kenya (i.e., analysis under alternative price or growth rate assumptions) could be used to estimate the time when supply and demand are likely to balance. This approach will be the basis of the formulation of a market development and improvement model that could find useful application in the sugar industry in Kenya.

Supply and Demand Analysis in Relation to the Sugar Industry in Kenya

Complete specification of a model would require the expression of the dependent variable as a function of all the factors that influence this variable. In practice, inclusion of all such factors in the estimating model is virtually impossible. The researcher should therefore specify the model in such a way that the number of coefficients in the complete model is reduced in order to make the estimation of the parameters feasible without sacrificing much of the information that should be obtained from the model. This statement implies that the model should satisfy the basic restrictions derived from the economic theory and be applicable in empirical studies.

Cane is the raw material for all sugar produced in Kenya. Sugar processors have to deliver all of their sugar output to a Government marketing agency, KNTC, for distribution. Frequent cane shortages result in the operation of sugar mills below their rated capacities. If the level of cane production could be raised and there was a necessity to establish more sugar mills in order to cope with increased cane supplies, the Government would finance such projects.[1] Given these facts, one can assert that increased supply of sugar from domestic sources will depend on how responsive the cane producers are to cane price changes. Hence the supply response analysis is done by examining the responsiveness of cane deliveries to the sugar mills and the related responsiveness of sugar supply to changes in cane and sugar prices respectively.

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[1] A basic concept in the theory of price formation.

Consumption of a given commodity is assumed to be inversely related to its price and directly related to the number of consuming units. However, consumers must have purchasing power so that the distribution of disposable income among the consuming units is an important consideration. The general level of prices and the purchasing power of consumers are normally taken into account in the analysis of demand by considering the real magnitudes of the prices and personal disposable income.

Supply Response Analysis: Theoretical Background

Agricultural production is characterized by relatively long maturation periods, i.e., from the time the decision to produce is made and implemented to the time the product is ready for the market. This time lag, which depends on the biological characteristics or the type of agricultural product, is crucial in the construction of an agricultural supply response model.[1] This section reviews the theory behind the models that are used in the analysis of the supply of sugar in Kenya.

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[1] See Government of Kenya, Development Plan, 1974/78 (Nairobi: Government Printer, 1974).

The nature of sugar supply response to cane and sugar price changes could be examined in terms of (i) the responsiveness of cane producers to cane price changes, and/or (ii) the responsiveness of the sugar suppliers to sugar price changes. Under the condition that increased sugar supply is being limited by shortages of cane deliveries to the mills, the first type of supply responsiveness needs more emphasis. Under this assumption, variations in the quantity of sugar produced and supplied in the market are explained by changes in the quantities of cane produced and delivered to the processing mills.

At a specified time period, the quantities of cane delivered to the mills are directly related to the cane acreage. For a given region, average yield tends to remain relatively constant over time. However, changes in average yield can occur as a result of the adoption of improved husbandry techniques, or new technologies in general. Hence changes in quantities of cane harvested and delivered to the mills could reflect either changes in cane acreage or improvements in husbandry techniques, or both. From such considerations, the analysis of supply responsiveness to price changes could be approached from any of the following three related aspects:

(i) Cane Acreage Response (CAR), which is largely determined by rates of planting and uprooting or destocking;

(ii) Cane Yield Response (CYR), which is normally influenced by such factors as land type, weather and state of technology;

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[1] For example, see M. Nerlove, "Estimates of Elasticities of Supply of Selected Agricultural Commodities," Journal of Farm Economics, Vol. 38, No. 2 (May 1956), pp. 496-509.

(iii) Total Production Response (TPR), which relates to the changes in the actual quantities of cane delivered to the mills for processing over time.

The latter type of supply response analysis (i.e., TPR) is considered to be the most appropriate approach in this study because this approach will generally encompass and directly account for changes in both the cane acreage and cane yields over time.

Cane is a semi-perennial crop which has an economically productive life of about six years, depending on altitude and harvesting techniques: the period between the time the cane is planted and the first harvest is about two years, but ratoon crops will normally take a shorter time to mature.[1]

Cane production can be regarded as a form of investment in farming whereby costs incurred now are related to a stream of net income in the future. Under this basic postulate in the theory of investment, cane producers are expected to vary the rate of cane planting, or at least vary the effort put into improving the husbandry techniques, according to expected profits. Expected profits can be defined as the difference between the expected returns and the total production cost. Expected profit is usually derived in terms of the discounted value of the returns from the investment. Generally, producers of cash crops are price-takers, and this is true in the case of cane production in Kenya, but they do have some control over output. Hence cane price is a major variable influencing the cane production decision and, consequently, the amount of sugar produced.

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[1] For instance, see J.D. Acland, East African Crops (London: Longman Group Ltd., 1971), pp. 192-201. After the so-called plant crop and the first two ratoon crops are harvested, yields decline geometrically. The crop becomes uneconomical to harvest and is ploughed out in order to plant a new crop.

The pioneer work on supply response analysis for agricultural products is attributed to Marc Nerlove (1956), who devised means to incorporate lags in the adjustment of agricultural supply to the changes in economic and institutional conditions. The long maturation period, from planting to harvesting, for most agricultural products is the main cause for such lags in the supply of agricultural products. To account for such lags, Marc Nerlove[1] formulated and introduced a lagged form of supply response model. This type of model has a lagged dependent variable as an explanatory variable. The coefficient of this explanatory lagged dependent variable reflects the magnitude of the coefficient of adjustment. The coefficient of adjustment, which is often referred to as the adjustment parameter, indicates the rate at which the adjustment of supply to changes in economic incentives can be expected to occur. The adjustment parameter is obtained from the estimate of the model by subtracting the estimated coefficient for the lagged dependent variable from unity.

Several models for forecasting supply of agricultural products have been developed and used in empirical studies since Marc Nerlove's work was published in 1956. All the conventional models for the analysis of the supply of agricultural products contain the lagged structure that was proposed by Marc Nerlove and are therefore said to be specified following the Nerlovian adjustment hypothesis.

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[1] M. Nerlove, "Estimates of Elasticities of Selected Agricultural Commodities," Journal of Farm Economics, Vol. 38 (May 1956), pp. 496-509.

A review of the various types of models that have been used in the analysis of the supply of agricultural products indicates that there are four types of models that could be used when forecasting the supply of perennial crops. The four types of models include two types of stock adjustment models, an adaptive expectations model, and a liquidity model.[1] Stock adjustment models apply to situations in which producers cannot adjust the area under the crop to the desired area within a cropping period. The adaptive expectations model is based on the assumption that producers take into account past and present prices while making their forecasts of the future prices on which production decisions are based, i.e., production decisions are based on price expectations. The liquidity model assumes that producers are constrained by finance while making their production decisions, which implies that high levels of plantings or production are expected following years of high earnings by producers. The adjustment parameter finds its main application in adaptive expectations and stock adjustment models.

Both the stock adjustment and adaptive expectations models are based on prespecified types of lag distribution schemes and are generally referred to as distributed lag models. These are the types of models whose application in the analysis of supply for agricultural products was popularized by Marc Nerlove.[2] The variant of the stock adjustment models that is usually used in the forecasting of supply of agricultural products is the partial adjustment model. Estimating models that are based on the specifications associated with both partial adjustment and adaptive expectations models are used in this study.

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[1] M.J. Bateman, "Supply Relationships for Perennial Crops in Less-Developed Areas," in C.R. Wharton, ed., Subsistence Agriculture and Economic Growth (Chicago: Aldine Publishing Company, 1969), pp. 243-253.

[2] M. Nerlove, The Dynamics of Supply: Estimation of Farmers' Response to Price (Baltimore: Johns Hopkins Press, 1958). This book was published after Marc Nerlove had published a number of articles on the supply of agricultural products in professional journals, for example, M. Nerlove, op. cit. (Journal of Farm Economics).

Partial adjustment models attribute lags in supply to ignorance, inertia and the cost of change. Adaptive expectations models attribute such lags to uncertainty and the discounting of current information on prices. Basically, the formation of expectations arises from periodic occurrence of changes in a deterministic variable. Hence the adaptive expectations model assumes that the expectations are updated each period by a fraction of the discrepancy between the current observed value of the variable and the previous expected value. The two types of model differ basically in the interpretation of the lag structure and the nature of the stochastic (disturbance) term. Otherwise there is no quantitative difference in the estimating equations of the adaptive expectations and partial adjustment models.[1] As Krishna shows, the specification of a pure expectations model for all explanatory variables results basically in the same structural estimating model as the one that results from a specification based on stock adjustment hypothesis.[2] However, neither of the two models is completely satisfactory as a supply analytic tool.

A major weakness of stock adjustment models is the assumption that the desired production level depends on current values of the independent variables. Similarly, adaptive expectations models suffer from the assumption that current production is adjusted immediately to the levels consistent with expectations, subject to a small discrepancy that can be relegated to a stochastic term. A more realistic specification of the model would incorporate both the stock adjustment and adaptive expectations hypotheses. However, for such a "combined" model, separation of the adjustment and expectations parameters from the estimated structural coefficients would be virtually impossible.[1]

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[1] See J. Johnson, Econometric Methods (New York: McGraw-Hill Book Company, 1972), p. 292.

[2] Raj Krishna, "Farm Supply Response in India-Pakistan: A Case Study of Punjab Region," in K.A. Fox and D.G. Johnson, eds., A.E.A. Readings in the Economics of Agriculture, Vol. XIII (Homewood: Richard D. Irwin, Inc., 1969), pp. 78-88.

The use of a model with lagged explanatory variables, as suggested in the Nerlovian adjustment hypothesis, and modifications of the lag distribution scheme can overcome some of the inherent weaknesses of stock adjustment and adaptive expectations models. The proposal here is to use a basic stock adjustment model that incorporates some elements of adaptive expectations on prices through the use of weighted price indices.

Supply Response Analysis: Model Specification

The basic assumption in the specification and derivation of the models used in the analysis of cane and sugar production is the notion that all past prices influence current levels of production through their effects on past production decisions. This notion is an element of adaptive expectations hypothesis. Under the production conditions in Kenya, a cane crop takes about two years to mature and only two ratoon crops are considered economic to harvest after the plant crop harvest.[1] Hence the economic life of cane is about six years, and all past prices dating back to five years can be expected to have some impact on the current level of production.

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[1] For instance, see J. Johnson, op. cit., pp. 303-307.

Following the Nerlovian adjustment hypothesis, the estimating model for the supply of agricultural products can be specified as:

$$\left.\begin{aligned} Y_t^* &= a_0 + a_1 X_{t-1} \\ Y_t - Y_{t-1} &= A(Y_t^* - Y_{t-1}) + U_t \\ 0 &< A \leq 1 \end{aligned}\right\} \qquad (4\text{-}5)$$

where A is the adjustment parameter, Y_t^* is the desired production level, X_{t-1} is the lagged explanatory variable (usually the price of the product), U_t is the stochastic variable, and a_0, a_1 are the underlying structural coefficients of the model. The closer to unity A is, the greater the amount of adjustment made in the current period. Since Y_t^* is unobservable, an operational version of the stock adjustment model specified in equations given as (4-5) above is obtained through the application of a Koyck transformation to yield:[2]

$$Y_t = Aa_0 + Aa_1 X_{t-1} + (1-A)Y_{t-1} + U_t \qquad (4\text{-}6)$$

Equation (4-6) is said to be operational because both the dependent and explanatory variables are now observable so that the model can be estimated.

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[1] After the first cane harvest, which is called the plant crop, the cane regrows and is cut two or more times before the fields are ploughed out and replanted. The second cane harvest is called the first ratoon crop. More ratoon crops are possible, thus extending the productive life of the crop, but yields decline geometrically with ratoon crops (see J.D. Acland, _op. cit_., pp. 192-201).

[2] For example, see P.N. Junankar, _Investment: Theories and Evidence_ (London: The Macmillan Press Ltd., 1972), pp. 32-36.

For convenience, equation (4-6) can be expressed as:

$$Y_t = b_0 + b_1 X_{t-1} + b_2 Y_{t-1} + U_t \qquad (4\text{-}7)$$

where $b_0 = Aa_0$; $b_1 = Aa_1$; and $b_2 = (1-A)$. Equation (4-7) forms the basis of the supply response estimating models used in the analysis. To make equation (4-7) more realistic as an estimating model, more explanatory variables are introduced in the estimating models. Hence the general production and supply estimating models could have own price (P_t), prices of competing produce (S_t), state of technology (T), a dummy variable (DV) to account for major policy changes, if any, and a weather or climatic variable (W_t) as the major explanatory variables for the observed production or supply levels. The production or supply estimating model can then be expressed as:

$$Q^s_t = b_0 + b_1 Q^s_{t-1} + b_2 P_{t-1} + b_3 S_{t-1} + b_4 W_t + b_5 T + b_6 DV + U_t \qquad (4\text{-}8)$$

which is a Nerlovian adjustment type of model, and where, keeping in line with the notations used in equations (4-5) through (4-7), $b_0 = Aa_0$; $b_1 = (1-A)$; $b_2 = Aa_2$; $b_3 = Aa_3$; $b_4 = Aa_4$; $b_5 = Aa_5$; and $b_6 = Aa_6$, while $Y_t \equiv Q^s_t$ and $X_t \equiv$ any explanatory variable in the model other than Q^s_{t-1} for which $Q^s_{t-1} \equiv Y_{t-1}$ is the relevant identity.

The model given by equation (4-8) basically depends on the stock adjustment hypothesis. To incorporate some elements of adaptive expectations in the model, a rational lag distribution scheme can be introduced in the estimating model. As specified, equation (4-8) results from a Koyck transformation and is thus based on a geometrically distributed lag scheme. Considering the biological characteristics of cane, yield of cane may be expected to be related to current and past prices through a rational rather than a geometric lag distribution scheme.[1] This implies that the weights assigned to current and past prices in order to incorporate their impact on current level of production should first rise and then fall gradually. A change in the price of cane this year would be expected to have a small effect this year, a bigger one the following two-to-three years, and then a geometrically declining effect in the subsequent years. Figure 4-3 illustrates the rational and geometric lag distribution schemes, where I_t represents the weight or impact of relevant price on the current level of production and is constrained such that:

$$\sum_{t=1}^{n} I_t = 1$$

Unlike the rational distributed lag scheme, the geometric distributed lag scheme assumes a continually declining influence of past prices on current production levels, so that immediate past is assumed to be more influential than the less recent past.[2] The rational distributed lag scheme can be approximated and incorporated in a model by weighting the prices in order to reflect the impact of past prices on production decisions and current output levels.

A weighted price index would modify the Nerlovian adjustment model of equation (4-8) by incorporating the impact of various past prices for a specified time period. For maize production, a one-year lag for

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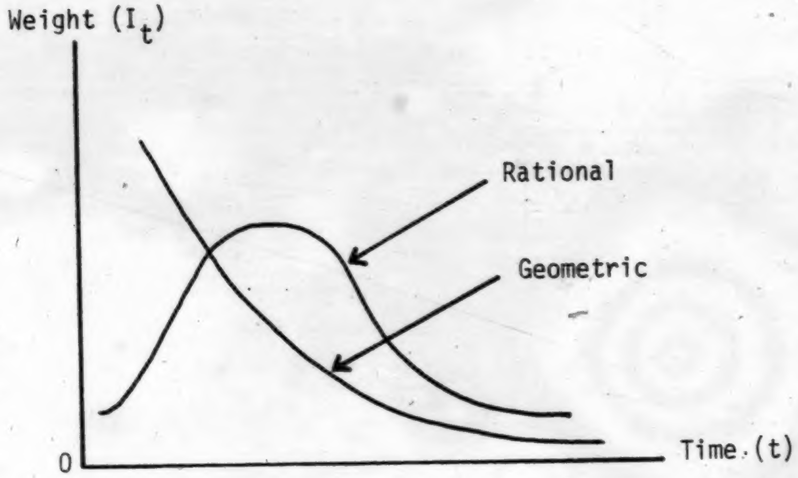
[1] See Figure 4-3 for the representations of rational and geometric distributed lag schemes.

[2] For example, see P.N. Junankar, Investment: Theories and Evidence (London: The Macmillan Press Ltd., 1972), pp. 32-36.

FIGURE 4-3

Distributed Lag Schemes



prices is used. For cane production, a five-year lag for prices is considered a reasonable approximation for this study. Therefore, a six-year weighted price of cane or sugar and a two-year weighted price of maize are used in the specification of the weighted prices model which can be expressed as:

$$Q_t^s = b_o + b_1 Q_{t-1}^s + b_2 P_t^* + b_3 S_t^* + b_4 W_t + b_5 T + b_6 DV + U_t \qquad (4\text{-}9)$$

where P_t^* is the six-year weighted price of cane or sugar, S_t^* is the two-year weighted price of maize, and all the other variables and notations are as given in equation (4-8).

Equation (4-8) gives what will be referred to as a lagged prices model (LPM) while equation (4-9) gives the weighted prices model (WPM). However, both models follow the Nerlovian adjustment hypothesis in that they have the coefficient of the lagged dependent explanatory variable Q_{t-1}^s as an indicator of the adjustment made in the current period. Results based on the two models will be compared and the model giving the best results in terms of statistical significance will be used in further analytical evaluations.

Some Comments on Supply Analysis Related Studies and Analytic Models

Forecasting of the supply of agricultural products is complicated by the fact that technology is relatively unstable and the level of output cannot be fully accounted for by the quantity of inputs.[1] The supply functions for agricultural products have been found to be relatively price inelastic, especially in the short-run. This observation is succinctly documented by Johnson, who attributes the price inelasticity of supply for agricultural products primarily to the conditions of the supply of inputs for agricultural production.[2]

A number of empirical studies on supply response analyses for agricultural products have been conducted, mainly for annual crops, and these have supported the hypothesis that the supply of agricultural products is relatively price inelastic.[3] These studies have also indicated that price is the major determinant of the supply of agricultural products.

Elasticity of supply measures the degree of responsiveness of the quantity supplied to the changes in price. Owing to technical and institutional factors, producers are usually not able to adjust their production immediately so that quantities supplied cannot be expected to respond immediately to changes in economic incentives. This lag in supply is measured by the adjustment parameter. Therefore, elasticity of supply and adjustment parameter are the important measures of supply that are employed in empirical studies of the supply of agricultural products.

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[1] T.W. Schultz, "Reflections on Agricultural Production, Output and Supply," in K.A. Fox and D.G. Johnson, eds., A.E.A. Readings in the Economics of Agriculture, Vol. XIII (Homewood: Richard D. Irwin, Inc., 1969), pp. 272-285.

[2] D.G. Johnson, "The Nature of Supply Functions for Agricultural Products," in K.A. Fox and D.G. Johnson, eds., Ibid., pp. 247-271.

[3] For example, see Marc Nerlove, "Estimates of Elasticities of Selected Agricultural Commodities," Journal of Farm Economics, Vol. 38 (May 1956), pp. 496-509; and Raj Krishna, "Farm Supply Response in India-Pakistan: A Case Study of Punjab Region," in K.A. Fox and D.G. Johnson, eds., op. cit., pp. 78-88.

There has been a divergence between the estimates of elasticity of supply and coefficients of adjustment for the same crop, depending upon whether the study was done for agriculture in developed or developing countries.[1] The major divergence has occurred in situations where the elasticity of supply, which is expected to be significantly positive, has been found to be insignificant, or even negative in some cases. This perverse response has been explained by the argument that increased prices could lead to smaller quantities being sold or supplied in the market.[2] However, these differences could be attributed to methodological approaches and the type of data used in the studies. Reliable and accurate data are rarely available in the case of peasant agriculture. Sometimes, the data recorded may refer to production in a small region within a given country, yet the models used in the analysis are constructed to cover a whole country. Researchers have, at times, been forced to use data of questionable reliability. Results of previous studies suggest that the significance of the coefficients of a regression model is influenced by the dominance of a given crop, either as a food crop or as a cash crop.[1] If such considerations could be incorporated in the models, maybe there would be small divergencies, if any, between the coefficients associated with supply response for crops produced in developing and developed countries.

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[1] Ibid.; and G.W. Mukasa-Mayanja, Econometric Analysis of the Supply of Cotton in Uganda: A Case Study of Six Cotton Zones, Unpublished M.Sc. Thesis, 1978, Department of Rural Economy, University of Alberta, Canada.

[2] For example, see H.M. Southworth and B.F. Johnson, eds., Agricultural Development and Economic Growth (Ithaca: Cornell University Press, 1970), pp. 390-405.

Typical studies on supply responses have been conducted in terms of the responsiveness of crop acreage to price changes. One may argue that producers have more control over crop acreage than over actual output and justify the conventional emphasis on crop acreage responses in empirical studies.[2] However, producers desire to increase their output levels when they increase crop acreage. Although the actual output may differ appreciably from the planned production, owing to the effects of factors beyond the producers' control, these effects should be systematic over time and the changes in actual output should directly indicate producers' response to changes in economic incentives over time. When pricing is used as a policy instrument to stimulate production, the policy maker is usually interested in the actual output. Hence the responsiveness of the quantities produced to price changes is the aspect that is of economic importance.

In this study, the analysis of sugar supply response is carried out in terms of output rather than acreage responsiveness to price movements for the following reasons:

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[1] See R. Krishna, "Farm Supply Response in India-Pakistan: A Case Study of the Punjab Region," in K.A. Fox and D.G. Johnson, eds., Readings in the Economics of Agriculture (Homewood, Illinois: Richard D. Irwin, Inc., 1969), pp. 78-88.

[2] For instance, see M.J. Bateman, op. cit., and J.R. Behrman, "Price Elasticities of the Marketed Surplus of a Subsistence Crop," Journal of Farm Economics, Vol. 48, No. 1 (1966), p. 875.

(i) Output is a product of crop acreage and the average yield, so that changes in crop yield or acreage are directly reflected in the output;

(ii) Producers could respond to changes in economic incentives by adopting improved crop husbandry techniques, or new technologies in general, which could lead to higher yields and increased output: such a possibility cannot be captured through acreage response analysis only;

(iii) Data availability and reliability: records of cane deliveries and quantities of sugar processed from year to year are obtainable from the mill operators (sugar processors). Similarly, records of all sugar imports are obtainable from the Government. All such records are considered accurate and reliable. On the other hand, data on cane acreage are scanty and are normally based on estimates. Hence the time series of domestic sugar production, consumption and imports are relatively accurate and reliable while those on cane yields and acreages, when available, are of doubtful reliability.

Proposition for a Dynamic Model of Supply Response Analysis (DSAM)

The commonly used models for the analysis of the supply of agricultural products are based on the Nerlovian adjustment hypothesis whereby a single parameter, the coefficient for the lagged dependent variable in the model, is used as a proxy for the rate at which production (or supply) adjusts to changes in economic incentives. In such models, lagging of explanatory variables is used as a technique for incorporating a dynamic structure. Such models are considered inadequate for the following reasons: (i) lagging of some explanatory variables alone is unlikely to result in complete specification of the dynamic structure of the model; (ii) for a given commodity, the planned production level in the immediate future may be expected to be influenced not only by the general price level for the commodity and competing produce, but also by the anticipated changes in this general price level.

Given the above reasons for dissatisfaction with the specification of the commonly used models in the analysis of the supply of agricultural products, the following hypotheses are made: (i) current level of production (Q_t^S) depends on previous level of production (Q_{t-1}^S) and is adjusted in accordance with the previous price levels for the given product (P_{t-1}) and competing produce (S_{t-1}) relative to anticipated changes in these price levels (dP/dt and dS/dt); (ii) previous weather condition (W_{t-1}) and the expected year-to-year changes in this weather condition (dW/dt) are also likely to influence the supply of the agricultural products, especially if the products are based on perennial crops (for annual crops, and products with a shorter gestation period, the prevailing weather condition (W_t) may be taken as the relevant explanatory variable).

Based on the above hypotheses, the dynamic structure of the usual Nerlovian adjustment types of model can be improved by introducing some indices based on the time derivatives of the explanatory variables in the estimating models as follows:

$$Q_t^S = b_0 + b_1 Q_{t-1}^S + b_2 \left(\frac{P_{t-1}}{PDEX}\right) + b_3 \left(\frac{S_{t-1}}{SDEX}\right) + b_4 \left(\frac{W_{t-1}}{WDEX}\right) + V_t \qquad (4\text{-}10)$$

where PDEX = (1 + dP/Pdt), SDEX = (1 + dS/Sdt) and WDEX = (1 + dW/Wdt) are the time-derivative-based deflators for the relevant explanatory variables.[1]

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[1] The behavioural assumptions of this model are still under scrutiny and will probably need some rigorous tests and evaluation.

Generally, models specified in the manner of equation (4-10) will be referred to as Dynamic Supply Adjustment Models (DSAM) in this study.

As equation (4-10) shows, the proposed model for dynamic supply analysis (i.e., DSAM) has a basic structure that involves the use of first lags and time derivatives of the relevant explanatory variables. The actual time derivatives are expected to influence the estimates of the usual structural coefficients that are determined in economic analysis. The actual specification of DSAM will depend on the assumed relationship between the dependent and the independent variables in the model, while the actual number of independent variables in the model will depend on theory or a priori information. For instance, a weather condition variable may be relevant for some products and not for others. The specification of DSAM as presented in equation (4-10) assumes a general linear relationship, with the variables as outlined under the hypotheses made above. The interpretations for the structural coefficients and the stochastic term are similar to those for the model specified in equation (4-9).

In order to examine or assess the validity of DSAM as an analytic tool, statistical tests of significance will be done on the estimates of DSAM using the time series data on cane and sugar production in Kenya. The same results will be compared with those based on the application of the usual Nerlovian adjustment types of model.

This paragraph presents some comments about the DSAM as specified in equation (4-10). First, based on economic theory, the expectations about the signs of the structural coefficients are as follows:

(i) $0 < b_1 \leq 1$

(ii) $b_2 > 0$

(iii) $b_3 < 0$

(iv) signs of b_0 and b_4 are subject to empirical determination.

Secondly, the DSAM has the lagged structure of the usual Nerlovian adjustment types of model[1] plus a more integrative dynamic structure that is achieved through the incorporation of the time derivatives of the explanatory variables in the model. The use of time derivatives is considered superior to the use of a time trend factor as a means of incorporating a dynamic structure in the model. Hence DSAM may be expected to be more reliable as an estimating model since it consists of a more complex structure than that of the usual supply estimating models. If this expectation were the case, then DSAM might yield either higher R-squared values or structural coefficients that are significant at higher significance levels than those associated with the coefficients based on the usual models. Examination of this statement is accomplished through statistical tests and comparisons of results associated with DSAM and alternative models.

The incorporation of time derivatives for relevant variables in the model can be likened to the method which was first used by A.B. Larson in an effort to make the simple cobweb model more realistic when explaining long cycles in agricultural production.[2] Larson proposes what he calls a "harmonic motion" model in which supply response (X) is a rate of change in planned production through time, so that the relevant model is expressed as:

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[1] This concept of Nerlovian adjustment models has been discussed in an earlier section.

[2] A.B. Larson, "The Hog Cycle as Harmonic Motion," Journal of Farm Economics, Vol. 46 (May 1964), pp. 375-386; and A.B. Larson, "The Quiddity of the Cobweb Theorem," Food Research Institute Studies, Vol. 7, No. 2 (Stanford, 1967), pp. 165-175.

$$\frac{dX}{dt} = kP \qquad (4\text{-}11)$$

where, at a specified time period, X is the planned production, P is the price of the product, and k is the structural coefficient for the model. However, the time derivative structure of DSAM differs from Larson's "harmonic" model in that rates of change occur in explanatory variables rather than in the dependent variable in the case of DSAM.

The lag and time derivative structures in the proposed DSAM could be modified to allow for different maturation and adjustment periods associated with various agricultural products. This modification would facilitate wider application of the DSAM in empirical analyses.

Finally, a note on the empirical estimation of the model is warranted. The relative rates of change in the general price levels of the given product and the competing products are estimated by taking the first differences for P_t and S_t in the model. The use of first differences is a quick and mathematically relevant method for approximating the derivative terms in a model. This technique is used in the approximation of dW/dt too, thus enhancing simplicity in the use of DSAM in empirical studies.

Demand Analysis: Theoretical Background and Demand Estimating Models

Economic theory tells us that the demand for a given commodity by an individual depends on the individual's taste or preferences, the price of the commodity, the prices of all other commodities, and the individual's income. Thus the ratio of the price of the given commodity and the prices of all other commodities, which is called the relative price, is a major determinant of the demand for the commodity. For a given commodity, the total demand function is derived as an aggregation for the individual demand functions. Hence, given the prices of all the commodities, the demand for a given commodity by an individual is determined simultaneously along with the demand for all other commodities within a given planning period, subject to the constraints imposed by the individual's income.

A number of models that could be used in the specification and estimation of demand functions have been advanced. Such models are either derived from a utility-maximization framework or are specified directly from economic theory with certain restrictions imposed. Basically, all the models used in empirical estimates of demand functions either employ the econometric methods, the input-output analysis technique, or some other forms of mathematical estimating techniques such as the extrapolation of straight lines or the trends.[1]

A recent publication by Hassan, et. al., (1977) notes that the three widely used demand estimating models based on utility-maximization comprise (i) the linear expenditure model, (ii) the indirect addilog model, and (iii) some other flexible function models. Notable applications of these models include the works of Houthakker (1960), Stone (1954), Parks (1969), Yoshihara (1969), and Christensen, et. al., (1977). These models are static in version.[2] C.E. McIntosh (1972) has used the linear expenditure model in the estimation of the demand for meat and dairy products in Canada.[3]

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[1] For instance, see A.C. Chiang, Fundamental Methods of Mathematical Economics (New York: McGraw-Hill, Inc., 1967).

[2] Z.A. Hassan, S.R. Johnson, and R. Green, Static and Dynamic Demand Functions: An Application to the Canadian Data (Ottawa: Agriculture Canada, November 1977), 31 pp.

[3] C.E. McIntosh, The Demand for Meat and Dairy Products in Canada with Projections for 1980, Unpublished Ph.D. Thesis, 1972, Department of Rural Economy, University of Alberta, Canada.

The linear expenditure model is derived from a utility function that was first proposed by Klein and Rubin,[1] and is applicable where the data on (i) the proportions of total expenditure on given commodities, (ii) the prices of these commodities, (iii) the quantities purchased of each commodity, and (iv) the consumer's total expenditure on the given commodities are available. The indirect addilog model, which was derived by Houthakker in 1960 and is based on the notion of an indirect utility function, has prices and income as its arguments. This model specifies the maximum utility level for a given set of prices and a particular income.[2] The flexible function types of demand models were proposed by Christensen, et. al., 1975 as an approach that can be useful in the testing of assumptions, such as the additivity of preferences, which are implicit in the other types of models cited above.[3] The salient feature of all these static demand models is that the utility function is derived either directly or indirectly from a set of prices and/or a particular level of income or expenditure.

The other forms of static demand models that are commonly used are based on direct specification. In a recent survey paper, Barten (1977) shows that these models can be grouped into (i) the Rotterdam demand system, and (ii) the Powell's system of additive preferences.[4] The

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[1] L.R. Klein and H. Rubin, "A Constant Utility Index of the Cost of Living," Review of Economic Studies, Vol. 15 (1947/48), pp. 84-87.

[2] H.S. Houthakker, "Additive Preferences," Econometrica, Vol. 28 (April 1960), pp. 244-257.

[3] L.R. Christensen, D.N. Jorgenson, and L.J. Lau, "Transcendental Logarithmic Utility Functions," American Economic Review, Vol. 65 (January 1975), pp. 37-54.

[4] A.P. Barten, "The Systems of Consumer Demand Functions Approach: A Review," Econometrica, Vol. 45 (January 1977), pp. 23-51.

Rotterdam demand system is based on the specification of the quantity demanded as a function of prices and a measure of real income, while the Powell's system of additive preferences is based on the specification of per capita expenditure as a function of prices, total expenditure, and a time-related variable to allow for shifts in consumer tastes. The two groups of models are more applicable in empirical estimates of demand functions than the models derived from a utility-maximization framework.

The static demand models assume that the consumer adjusts instantaneously to a new equilibrium when income or prices change. Normally, the adjustment process would be expected to take some time, owing to habit formation and some other influences. Hence, static demand models can often yield results indicating that consumers are not behaving in an optimal manner, when in reality the models are ignoring the many adjustments that are likely to occur in the short run. To account for these deficiencies, the incorporation of dynamic structures into the specification of demand systems has been used as one solution.

The various approaches made to incorporate dynamic structures in empirical demand systems can be classified into three broad categories.[1] The first category includes several ad hoc procedures that represent different degrees of sophistication. The simplest of these models involves the addition of trend variables to the demand equations derived from the classical static theory. The objective is to reflect changes in tastes and other socio-economic factors through the trend term. Closely related to this approach is the introduction of a trend term into the parameters of models based on classical theory (Stone [1964]). However, the theoretical justification for the additive trend terms is limited. The most sophisticated model in the first category is the state adjustment model which was first proposed and used by Houthakker and Taylor in 1970.[1] This model assumes that quantities purchased depend on existing stocks--either physical stocks of goods or psychological stocks of habits. This specification explicitly introduces the influence of the past consumption behaviour on current consumption patterns.

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[1] Z.A. Hassan, et. al. (1977), op. cit., p. 7.

The second category of models which attempt to capture the observed persistence in consumption patterns in the structure of demand functions involves the use of dynamic utility functions. The utility function is made dynamic by directly incorporating the changes in tastes. This approach is exemplified by the quadratic model of Houthakker and Taylor (1970)[2] and the dynamic linear expenditure system of Phlips (1974).[3] All these models are based on the assumption that current expenditure allocation is influenced by past consumption; the effects of current expenditure allocation on future preferences are ignored.

The third, and final, category of dynamic demand estimation models comprises models which integrate both past and future considerations into one systematic treatment of the consumer choice problem.

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[1] H.S. Houthakker and L.D. Taylor, Consumer Demand in the United States (Cambridge, Mass.: Harvard University Press, 1970).

[2] *Ibid.*

[3] L. Phlips, Applied Consumption Analysis (Amsterdam: North-Holland Publishing Company, 1974).

The models are based on the assumption that the consumer is attempting to maximize a discounted utility function subject to income and stock constraints. Examples include the models developed by Phlips (1974)[1] and Lluch (1974).[2] The models in the third category involve the application of the optimal control theory, so that consumption is modelled as a sequential decision problem.

The first category of dynamic demand models will be used in this study, the choice being based on empirical grounds. Two general types of models will be applied in the estimation of the demand function for sugar in Kenya: (i) the classical demand model, derived directly from economic theory, with a time-related variable introduced to account for changes in tastes and other socio-economic factors, and (ii) the state adjustment model. The two types of models and their variants are discussed below.

The Classical Demand Analysis: Dynamic Model

Two variants of the classical demand model can be specified as follows:

$$\text{(i)} \quad Q_t^d = a_0 + a_1 P_t + a_2 Y_t + a_3 T + U_t \qquad (4\text{-}12)$$

$$\text{(ii)} \quad Q_t^d = a_0 P_t^{a_1} Y_t^{a_2} T^{a_3} e^{U_t} \qquad (4\text{-}13)$$

where: Q_t^d = quantity of commodity consumed;

P_t = price of commodity;

Y_t = disposable income;

T = time trend variable;

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[1] Ibid.

[2] C. Lluch, "Expenditure, Savings and Habit Formation," International Economic Review, Vol. 15 (October 1974), pp. 786-797.

U_t = stochastic variable;

and a_0, a_1, a_2, and a_3 are the underlying structural parameters of the models to be estimated. The stochastic variable U_t is introduced to account for all other minor variables that influence the demand.

The models given by equations (4-12) and (4-13) may define either individual or aggregate demand functions depending on the assumptions made about the quantity variable Q_t^d and the income variable Y_t. Further, the models can be modified through alternative specifications, based on the assumptions about the way the various variables enter the model. For instance, the time trend factor may be assumed to enter the model multiplicatively, as in equation (4-13), or additively even in an otherwise logarithmic demand model. Hence results based on different model specifications will be assessed before choosing the final type of model specification to be used for further analytical work.

The State Adjustment Model (SAM)

The state adjustment model was first derived and applied in demand analysis by Houthakker and Taylor in 1970.[1] The original model specification can be given as:

$$q_i = a_0 + a_1S_i + a_2y + a_3P_i \tag{4-14}$$

where, at a specified time period and for the i^{th} commodity:

q_i = the quantity demanded;

y = per capita income;

P_i = relative price;

S_i = the stock of the commodity.

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[1] H.S. Houthakker and L.D. Taylor, op. cit.

The stock of the commodity may be viewed either as a physical stock in the case of durable goods or as a psychological stock of habits in the case of habit-forming goods. For equation (4-14), a_o, a_1, a_2, and a_3 are the underlying structural parameters of the model, with $a_1 > 0$ for habit-forming goods and $a_1 < 0$ for durable goods. Further, the following assumption is made:

$$\frac{dS_i}{dt} = q_i - bS_i \qquad (4\text{-}15)$$

where b is a constant depreciation rate for the stock of commodity, which is normally taken to be positive.

Equations (4-14) and (4-15) constitute the basic state adjustment model. Equation (4-14) indicates that the quantity demanded is determined by the quantity in stock, price and income while equation (4-15) relates the rate of change in stock to the rate of purchase and the depreciation rate.

The basic model is modified in several ways in empirical analysis: the unobservable variable S_i is eliminated by solving equation (4-14) for S_i and using equation (4-15) to yield:

$$\frac{dS_i}{dt} = \left[q_i - \frac{b}{a_1}(q_i - a_o - a_2 y - a_3 P_i)\right] \qquad (4\text{-}16)$$

By differentiating equation (4-14) with respect to time, and using equation (4-15), $\frac{dq_i}{dt}$ can be solved for from the relationship:

$$\frac{dq_i}{dt} = \left[a_o b + (a_1 - b)q_i + a_2\frac{dy_i}{dt} + a_2 \cdot by_i + a_3 \cdot \frac{dP_i}{dt} + a_3 bP_i\right] \qquad (4\text{-}17)$$

Equation (4-17) includes variables that are observable in principle and is the empirical version of the state adjustment model. However, for applicability, equation (4-17) has to be expressed in a discrete time version: this can be accomplished by using first differences and letting $S_t = (S_t - S_{t-1})/2$. From these approximations, and rearranging the terms, the following expression is obtained:

$$\begin{aligned} q_t = \Bigg[& \left(\frac{a_0 \cdot b}{1-\frac{1}{2}(a_1-b)} + \frac{1+\frac{1}{2}(a_1-b)}{1-\frac{1}{2}(a_1-b)} \cdot q_{t-1} + \frac{a_2(1+\frac{1}{2}b)}{1-\frac{1}{2}(a_1-b)} \cdot \Delta y_t \right. \\ & \left. + \frac{a_2-b}{1-\frac{1}{2}(a_2-b)} \cdot y_{t-1} + \frac{a_3(1+\frac{1}{2}b)}{1-\frac{1}{2}(a_1-b)} \cdot \Delta P_t + \frac{a_3 b}{1-\frac{1}{2}(a_1-b)} \cdot P_{t-1} \right) \Bigg] \end{aligned} \qquad (4\text{-}18)$$

Equation (4-18) can be re-written as:

$$q_t = \left(A_o + A_1 q_{t-1} + A_2 \Delta y_t + A_3 y_{t-1} + A_4 \Delta P_t + A_5 P_{t-1} \right) \qquad (4\text{-}19)$$

so that:

$$a_o = \frac{2A_o(A_2 - \frac{1}{2}A_3)}{A_3(A_1+1)} \qquad (4\text{-}20\text{-}1)$$

$$a_1 = \frac{2(A_1-1)}{A_1+1} + \frac{A_3}{A_2 - \frac{1}{2}A_3} \qquad (4\text{-}20\text{-}2)$$

$$a_2 = \frac{2(A_2 - \frac{1}{2}A_3)}{A_1+1} \qquad (4\text{-}20\text{-}3)$$

$$a_3 = \frac{2(A_4 - \frac{1}{2}A_5)}{A_1+1} \qquad (4\text{-}20\text{-}4)$$

and

$$b = \frac{A_3}{A_2 - \frac{1}{2}A_3} = \frac{A_5}{A_4 - \frac{1}{2}A_5} \qquad (4\text{-}20\text{-}5)$$

The above analytical technique results in two expressions for b, and these are not necessarily the same (see equation [4-20-5]). Hence an average value for b can be calculated from the two estimates. To ensure that an unambiguous estimator for b is obtained, equation (4-19) would have to be estimated subject to the constraint that $A_2A_5 = A_3A_4$, which requires special programming.

Parameters a_2 and a_3 give the derivatives of consumption with respect to income and price respectively for the short-run SAM. The long-run SAM is obtained by assuming that, in the limit, equation (4-15) takes the form:

$$\frac{dS}{dt} = q_i - bS_i = 0 \qquad (4\text{-}21)$$

Equation (4-21) implies that the stock adjustment has reached an equilibrium state.

Substitution of equation (4-21) into equation (4-14) yields the expression:

$$q_i = a_o + \frac{a_1}{b} \cdot q_i + a_2 y + a_3 P_i \qquad (4\text{-}22)$$

which, upon re-arranging, gives:

$$q_i = \frac{a_o \cdot b}{b-a_1} + \frac{a_2 \cdot b}{b-a_1} \cdot y + \frac{a_3 \cdot b}{b-a_1} \cdot P_i \qquad (4\text{-}23)$$

Equation (4-23) can be re-written as:

$$q_i = c_o + c_1 y + c_2 \; P_i \qquad (4\text{-}24)$$

where $c_o = \dfrac{a_o \cdot b}{b-a_1}$

$$c_1 = \frac{a_2 \cdot b}{b-a_1}$$

$$c_2 = \frac{a_3 \cdot b}{b-a_1}$$

Hence the derivatives of consumption with respect to income and price for the long-run SAM are c_1 and c_2 respectively, which, from equation (4-23), requires that $b \neq a_1$. Income and price elasticities are obtained by multiplying the derivatives of consumption with respect to income and price with the quotients of average (i) consumption and income and (ii) consumption and price respectively. Thus the short-run and long-run income and price elasticities can be generated from the state adjustment model. Equations (4-19) and (4-24) are the versions of the state adjustment model (SAM) used in empirical analysis. Both models will be used in the estimation of demand functions for sugar in Kenya.

Concluding Remarks on Models for Demand Analysis

As outlined above, various approaches have been made in the formulation and empirical estimation of models for the analysis of demand. Recognition of the possibility of lags in purchasing or adjustment in consumption patterns following price and/or income changes, primarily due to existence of stocks or habit formation, can be regarded as a major break from the classical thought in which adjustment is perceived as instantaneous. Hence the state adjustment model is regarded as an appropriate tool in the analysis of demand for sugar.

Equations (4-12) and (4-13) give the commonly used models in empirical demand analysis. A major weakness in some studies is to ignore specific incorporation of the number of consuming units as an influencing variable in the demand system, except when the models used are specified on a per capita basis. When models similar to equations (4-12) and (4-13) are used, population figures could be included as separate influencing variables in the model in order to bring out the effect of the number of consuming units on the level of demand.

Estimation Techniques and the Common Econometric Problems

The basic estimation procedures involve the use of statistical and econometric methods. The general linear model forms the basis of the estimating models used in the study. The basic estimation technique used in the study comprises the method of least squares.[1] The actual estimation technique that is used depends on what is known about the model to be estimated. For instance, some econometric problems that could render the estimates of a model unreliable may be present and remedial procedures must be taken before reliable estimates of the model can be obtained.[2]

The common econometric problems that could render the estimates of a model unreliable, unless appropriate remedial measures are taken, include serial correlation (autocorrelation), heteroscedasticity and multicollinearity. These problems are rooted in the nature of the data used and not in the estimation technique. For instance, autocorrelation is a problem that occurs primarily in time series rather than cross-section data, while heteroscedasticity is more likely to occur in cross-section rather than time series data. Multicollinearity may occur in both cross-section and time series data, although the incidence might be higher in the latter type of data. Except for autocorrelation that is associated with time series data, the other econometric problems cannot be assigned specifically to either cross-section or time series data.

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[1] Details of the basic estimation procedures and discussions of the assumptions of the general linear model, including the least square estimation techniques, can be found in such textbooks as: (i) M. Dutta, Econometric Methods (Cinicnnati, Ohio: South Western Publishing Co., 1975), 382 pp.; (ii) H. Theil, Principles of Econometrics (New York: John Wiley & Sons, Inc., 1971), 736 pp.; and (iii) J. Johnson, Econometric Methods (New York: McGraw-Hill Book Co., 1972), to mention a few. However, a statement of the basic properties of the least squares estimation technique is given in the Appendix.

[2] Specific discussions of such remedial measures that are taken in order to facilitate model estimation can be found in the section on analysis in Chapter V of the thesis; some details are relegated to the Appendix to the thesis.

The presence of a lagged dependent variable as an explanatory variable in a model poses estimation problems, yet the insertion of such lagged variables in the models is justified on economic grounds.[1] The types of models that are frequently used in the analysis of the supply of agricultural products, namely the partial adjustment and the adaptive expectations models, contain a lagged dependent variable in the set of their explanatory variables. Estimation of such models requires certain remedial procedures in order to improve the reliability of the estimates. Such remedial measures depend on what is either assumed or known about the scheme of distribution for the stochastic variables in such models.

Possible schemes of distribution of the stochastic variables for models having lagged dependent variables as explanatory variables include the following:[2]

A: the stochastic variables may be independently and normally distributed with zero means and constant variances;

B: the stochastic variables may be of the moving-average type;

C: the stochastic variables may be simply autocorrelated.

Under scheme A, there is no serial correlation and the only problem in the model would be the presence of a lagged dependent variable in the set of the explanatory variables for the model. This description fits the structure of a partial adjustment model. Scheme B fits the description of an adaptive expectations model; scheme C allows the stochastic variable to follow the simplest possible non-random scheme without tying the model to prespecified lag distribution schemes. Under scheme C, serial correlation is defined by the first-order Markov scheme.

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[1] J. Johnson, Econometric Methods (New York: McGraw-Hill Book Company, 1972), pp. 292-321.

[2] Ibid., p. 304.

Under scheme A, there is no serial correlation, but the stochastic variable is no longer uncorrelated with all the explanatory variables so that OLS estimates would be biased for finite samples, the direction being negative, i.e., the OLS estimates are likely to underestimate the true values of the parameters.[1] However, the estimates would be asymptotically unbiased, which implies that the reliability of the estimates can be improved by increasing the size of the sample. The other schemes define models having disturbance terms that are serially correlated, and the estimation of such models poses some extra problems since both the lagged dependent variable that is an explanatory variable in the model and the serially correlated disturbance term must be considered.

The presence of serially correlated stochastic variables in the absence of explanatory lagged dependent variables in the model does not make OLS estimates biased even in finite samples, but the presence of the explanatory lagged dependent variable, even in the absence of serially correlated stochastic variables, makes OLS estimates biased for finite samples. The combination of the two problems, i.e., lagged dependent variables in the explanatory set and serially correlated stochastic variables, gives OLS estimates that are both biased and inefficient.[1] As mentioned in an earlier paragraph, the presence of explanatory lagged dependent variables alone produces a negative bias for the estimates in the case of finite samples. However, the combination of the problem of explanatory lagged dependent variables and serially correlated stochastic variables in the model produces a positive bias that persists at all levels of sample size.[2]

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[1] J.S. White, "Asymptotic Expansions for the Mean and Variance of the Serial Correlation Coefficient," Biometrika, Vol. 48 (1961), pp. 85-94. Note that OLS stands for Ordinary Least Squares as an estimation technique (see Appendix A-5).

Estimation methods other than OLS should be used if there is evidence that the stochastic variable in a model having explanatory lagged dependent variables is serially correlated. This observation gives the essence for taking appropriate remedial procedures for serial correlation before obtaining the least square estimate of such a model. The usual estimation procedure under such conditions is referred to as GLS (generalized least squares) estimation technique. Given the nature of the models that are used when forecasting the supply of agricultural products, which are normally specified following the Nerlovian adjustment hypothesis, special attention is paid to (i) tests for the presence of econometric problems in the estimating models, and (ii) application of appropriate remedial measures before obtaining the least square estimates for the models used in this study. The validity and reliability of such estimates are then assessed through statistical tests of significance.

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[1] J. Johnson, op. cit., p. 308.

[2] Ibid.

Tests of statistical significance for the estimated structural coefficients of the models are executed by comparing the calculated and the standard t-statistic values. The overall statistical significance of the estimated model (the regression line) is assessed by comparing the calculated and the standard F-statistic values. The F-statistic test directly determines the significance of the calculated coefficient of determination (the R-squared value) for the estimated model: this test gives what is commonly called the goodness of fit for the estimated model. The tests or scanning techniques that are executed in order to detect the presence of econometric problems include (i) the Durbin-Watson d-statistic and h-statistic tests for autocorrelation (serial correlation); (ii) the Goldfeld and Quandt test and Spearman's rank correlation coefficient test for heteroscedasticity; and (iii) Farrar-Glauber tests for multicollinearity. The results of the various statistical tests are presented in the relevant sections of the thesis.

Statistical tests of significance are usually conducted at the 0.01 and 0.05 significance levels. However, due to the use of time series data, and small sample sizes in some cases, results that are found to be significant at 0.1 significance level are also considered to be reliable. The presence or absence of such econometric problems as autocorrelation, heteroscedasticity and/or multicollinearity has important implications on the reliability of the estimated coefficients. If the presence of any of these econometric problems is confirmed, then appropriate remedial measures for such a problem are taken before obtaining any estimates of the structural parameters of the model that can be considered reliable.

A price-formation hypothesis will be examined during the course of model estimations. The purpose will be to examine if the regulation of the sugar market by the Government has had an impact on the normal rate of market adjustment in terms of prices. From theoretical considerations, one may expect that there are some differences between the estimates of the structural coefficients of models that are defined within a recursive equations framework and those for the models defined within a simultaneous equations framework.[1] Simultaneous equations models may be regarded as giving conditions when the economic agents (both producers and consumers) are behaving optimally. In order to examine the validity of the preceding statements, estimates of the supply and demand functions for sugar in Kenya will be carried out under the assumptions of (i) recursively determined equations models, and (ii) simultaneously determined equations models. The results will then be compared and contrasted.

Instrumental variable technique (IVT) can be used when estimating equations from a simultaneous equations model. The IVT estimation procedure involves the determination of which explanatory variables in the estimating model are exogenous. Variables that are determined within the model are said to be endogenous; those that are determined outside the model are said to be predetermined or exogenous. The dependent variable in a model is usually regarded as endogenous, but the independent variables set can consist of either exogenous or endogenous variables, or a mixture of the two. Once the endogenous explanatory variables in the model to be estimated using the IVT procedure have been determined, these variables are then expressed in terms of their principal components. The components that are exogenous are used to replace the appropriate explanatory variables in the model. Such components must satisfy at least two conditions if they are to be used in the model as instrumental variables:[1]

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[1] A discussion and treatment of recursive demand and supply systems and simultaneous equations models of supply and demand can be found in applied econometric textbooks such as K.F. Wallis, Topics in Applied Econometrics (London: Gray-Mills Publishing Ltd., 1973); and D. Orr, Applied Econometrics. Toronto: Institute for Policy Analysis, University of Toronto, 1977.

(i) The instrumental variable must be truly exogenous and independent of the stochastic term: if Z is the matrix of the instrumental variables and U is the vector of the stochastic terms, this condition requires that $E(UZ) = 0$;

(ii) The instrumental variable must vary substantially enough to have an impact on both the original explanatory variables set (X) and the dependent variable (Y) so that, using the notations of (i) above, $E(YZ) \neq 0$ and $E(XZ) \neq 0$.

Identification problem is a phenomenon that is likely to be encountered when estimating models using the instrumental variable technique. In this context, the term identification is used to refer to whether one can or cannot estimate a given equation from the complete model depending on the given information. In order to avoid identification problem in the estimation of models, particularly for simultaneous equations models, one must ensure that the number of exogenous variables not included in the equation to be estimated is at least equal to or greater than the number of endogenous variables in the equation less unity. That is, if G is the number of endogenous variables in the equation to be estimated, K is the number of exogenous variables in the complete simultaneous equations model, and K^* is the number of exogenous variables included in the equation to be estimated, then identification in this context requires that:

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[1] See M. Dutta, Ibid., pp. 241-255.

$$(K - K^{*}) \geq (G - 1)$$

Normally, the order condition for an equation is calculated in order to determine if the equation is identified. Defining $K^{**} = (K-K^{*})$ the order condition (R^{*}) is given by:

$$R^{*} = K^{**} - G + 1$$

If: $R^{*} = 0$, the equation is just identified;

$R^{*} < 0$, the equation is underidentified;

$R^{*} > 0$, the equation is overidentified.

Underidentified equations cannot be determined or estimated empirically from the given information using the IVT procedure, i.e., only the equations for which $R^{*} \geq 0$ are estimable using the IVT procedures. The two-stage least squares (TSLS) estimation technique, which is a special case of the instrumental variable estimation technique, is the method that is used in the estimation of the simultaneous equations model of supply and demand for sugar in this study.

Projections and Forecasts

A projection may be defined as an estimate of the consequence of the operation of specified influence under certain specified assumptions. Hence a projection presents a "would be if ...." results. On the other hand, a forecast may be defined as a statement of a consequence which is expected to occur. Hence a forecast presents a "will be ...." results.[1] An understanding of the two concepts is important for a clear understanding of predictive studies.

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[1] FAO, Agricultural Commodity Projections, 1970-1980, Vol. 1 (FAO, Rome, 1971), p. 4.

Projections and/or forecasts are useful in agricultural or economic development planning. Distinguishing between a projection and a forecast is possible only if the initial assumptions about the prediction are examined. Since most statements about a future outcome are made under a specified set of assumptions, projections are more commonly used in predictive studies.

A number of projection and forecasting techniques can be used. These include mathematical extrapolation of trends or estimated regression lines, the use of the basic discounting or compounding methods, and the substitution of relevant estimated parameters in predicting models. The basic discounting or compounding method and a predictions model through which the estimated structural parameters of the supply and demand functions can be applied in the projections of production and consumption of sugar in Kenya during the next two decades will be developed and applied in the next chapter [see equations (5-18) through (5-23) in Chapter V].

Summary

This chapter has presented a review of some basic concepts in economic theory that are useful in the understanding of supply and demand analysis, the presentation being biased toward a discussion of supply and demand functions. The various factors that influence the levels of supply and demand have been discussed, and the reasons for the conventional use of empirically determined supply functions, rather than production functions, as policy guides for production have been given. The chapter has also presented a review of the analytic models that will be used in the analysis of the sugar market in Kenya in accordance with the main objectives set for the study.

In the review of the analytical models, special emphasis was placed on the estimation methods and the common econometric problems that pose estimation problems. The theory behind the various analytic models was discussed briefly and some weaknesses of the various models were discussed before making propositions for model modifications in order to improve their reliability or validity as analytic tools. Such considerations and propositions led to the formulation of dynamic analytic models that are tested in the next chapter. Finally, a discussion of prediction methods and models for the projections of quantities supplied and/or demanded was presented. Such methods will be used in the projections of production and consumption of sugar in Kenya.

CHAPTER V

DATA AND DATA ANALYSIS, EVALUATIONS AND APPLICATIONS OF THE ANALYTIC RESULTS

Data and Data Analysis

Introduction

Time series data constitute the bulk of the data used in the study. However, some of the information used in the description of Kenya's sugar industry was gathered through personal interviews with Government personnel and other officers who handle matters related to the sugar industry. Such data were collected by the author of this thesis during the period between September 1976 and June 1977. Hence some changes may have occurred in the organization of the industry since then.

The specific data relevant to the sugar industry in Kenya that are needed for the study include time series of (i) quantities of cane produced and delivered to sugar mills for processing; (ii) producer cane prices; (iii) a price index for the commodity whose production is competitive to cane and sugar production; (iv) an index of average weather or climatic conditions for the major cane producing zones; (v) quantities of sugar processed by the sugar mills; (vi) quantities of sugar imported into the country; (vii) quantities of sugar consumed in the country; and (viii) domestic wholesale and retail prices of sugar. Other data requirements comprise the time series of national and per capita disposable income in Kenya, the consumer price index for Kenya, the world market price of sugar, and results from relevant previous studies that could be used in the assessment and evaluation of this study. The various data are presented in Tables 5-1 through 5-5.

The Criteria for the Admissibility and the Choice of Data

The history of recorded development of agriculture in Kenya may be said to date back to 1920 when Kenya was colonized by the British. However, such developments were confined to the arable Kenyan highlands which were occupied by the British settlers. There was no government plan for a country-wide development of agriculture prior to the Swynnerton Plan of 1954 which called for the intensification of agriculture by the African populace.[1] For this reason, 1954 can be taken as a general starting point in the study of agricultural development in Kenya. This study is thus based on the analysis of time series data for periods between 1954 and 1977.

Another important date in the history of the changes in the policy for the development of agriculture in Kenya is 1963, the year when the country became a sovereign state. The new government took office at the end of 1963, and new development plans were formulated. A self-sufficiency food production policy was a chief feature among the new development policies.[2] Hence 1964 can be taken as a starting point for a structural change, particularly in the variables defining economic relations. Existence (or absence) of such structural changes can be tested for, for instance through the Chow test.

At least four major sugar markets in the world can be identified. These include (i) the United States sugar market, which had been governed by the United States Sugar Act up to 1975; (ii) the European Community sugar market; (iii) the Communist Bloc sugar market; and (iv) the residual sugar market, which is often referred to as the free world sugar market and has hitherto been governed by a number of successive International Sugar Agreements (ISA). In the past, Commonwealth countries traded under general conditions that had been specified in successive Commonwealth Sugar Agreements (CSA).[1] However, CSA became defunct upon the accession of the United Kingdom (UK) to the European Economic Community in 1974. Despite the existence of the so-called preference sugar markets outlined under (i), (ii) and (iii) above, any country in the world can participate in ISA negotiations. If such a country then decides to be a signatory to the Agreement (ISA), it can sell or buy sugar in or from the residual market which is described under (iv) above. For this reason, the International Sugar Organization (ISO) composite price is used in the evaluation of the influence of the world market sugar price on the domestic price in Kenya. This composite sugar price has been shown to follow the same general trend as the United States and the Commonwealth sugar prices in the past, thus indicating that there is some degree of market integration among the various markets for sugar in the world.[2]

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[1] For instance, see J. Heyer, et. al., ed. Agricultural Development in Kenya: An Economic Assessment (Nairobi: Oxford University Press, 1976), pp. 125-147.

[2] See, for example, Government of Kenya, Development Plan, 1966/1970 (Nairobi: Government Printer, 1966).

In addition to the above data which are to be sought, any other relevant data or information will be used where appropriate. For instance, a dummy variable can be used in the estimating models if there is a theoretical justification for such an incorporation and if this is likely to improve the predictive power of such models. The required time series data for the period between 1954 and 1977 were obtained from the Kenya Government and the United Nations (UN) publications or records. Hence such data are regarded as accurate or reliable records of the required information.

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[1] For more information on the various world markets for sugar, see Chapter II of the thesis.

[2] G. Gemmill, "The World Sugar Economy: An Econometric Analysis of Production and Policies," Agricultural Economics Report No.313 (Dept. of Agric. Economics, Michigan State University, 1976), pp. 8-11.

Data Treatments

Production of cane and sugar in Kenya has shown a general upward trend over the last two decades, as can be deduced from Tables 5-1 and 5-2. However, there have been some periods of shortfalls in production, for instance during the 1966/67 and 1972/73 crop years. Such periods of shortfalls have generally been attributed to natural hazards, such as prolonged periods of drought, and little or no consideration has been given to possible influence of the general economic condition on the level of production.[1]

Several measures or proxies for the average weather or climatic conditions could be conceptualized, depending on the geographic regions considered. Under the Kenyan condition, or for tropical conditions in general, the average amount of rainfall and its distribution throughout the year are the major determinants of crop production as far as the weather conditions are concerned. Generally, the incorporation of an average weather index in a supply response estimating model might enable the analyst to isolate the effect of economic conditions on the observed changes in production.

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[1] Government of Kenya, Economic Survey (Nairobi: Government Printer, Various Issues up to 1976).

TABLE 5-1

Cane Production and Producer Cane Prices in Kenya, 1961-1976

Year	Quantities of Cane Delivered to Mills [Thousand Metric Tons]	Producer Cane Prices [Kshs. per Metric Ton]	*Area of Land Under Cane Crop (LSF) [Thousand Hectares]
1976	2053.5	105	29.3
1975	1735.4	89	27.1
1974	1719.1	62	26.9
1973	1545.1	52	28.1
1972	1062.3	50	26.4
1971	1378.0	45	26.1
1970	1451.2	45	26.5
1969	1300.7	45	21.9
1968	947.2	45	17.1
1967	706.4	42	18.3
1966	514.6	42	18.4
1965	517.7	42	18.5
1964	600.9	42	18.1
1963	512.5	37	17.8
1962	498.4	37	17.1
1961	496.2	37	14.6

*LSF = Large Scale Farms. Data for Small Scale Farms (SSF) are not available.

SOURCE: Government of Kenya: (i) Statistical Abstract; and (ii) Economic Survey (Nairobi: Government Printer, Various Annual Issues up to 1976).

The average weather index employed in the study is based on the mean annual rainfall received in the three major cane-producing zones of Kenya. The country has a typical bimodal rainfall distribution, most of the rain being received during the March-May and September-November periods. Table 5-2 presents time series of the average weather index and the quantities of sugar produced in Kenya during the last two decades, ending in 1976. As would be expected, the weather index does not exhibit any general trend and is random in nature.

The general economic environment has a direct influence on the levels of both production and consumption. The supply of a given commodity is not only influenced by the price of that commodity, but also by the prices of the other commodities, particularly for those whose production exhibits a competitive relationship. The index of the cost of living, which is commonly presented as a consumer price index (CPI), can be used as a general indicator of the economic condition in a country. Hence this index is normally used to deflate the prices of individual commodities[1] and the disposable income when conducting economic analysis. The main enterprises that compete with cane and sugar production are discussed in Chapter III whereby maize production is shown to be the enterprise that can be considered to pose effective competition to cane and sugar production. Hence an index of maize prices is used as a proxy for the prices of other commodities in the supply estimating models. The various prices and price indices are presented in Table 5-3.

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[1] The price of each commodity must be assumed not to contribute significantly to the composite CPI, if such a CPI is used as a general deflator for the individual time series of prices.

TABLE 5-2

Average Weather Index and Sugar Production in Kenya, 1955-1976

Year	*Average Weather Index: 1970=100	Domestic Sugar Production [Thousand Metric Tons]
1976	99.73	190
1975	95.57	180
1974	81.84	163
1973	107.32	138
1972	119.18	92
1971	89.44	124
1970	100.00	125
1969	90.30	115
1968	130.29	81
1967	108.96	60
1966	105.46	36
1965	98.42	29
1964	99.72	35
1963	110.48	38
1962	59.25	33
1961	67.22	33
1960	105.48	30
1959	99.74	28
1958	67.79	28
1957	93.48	20
1956	72.72	20
1955	72.41	17

*Based on Average Monthly Rainfall for the Major Cane-producing Zones of Kenya.

SOURCE: Government of Kenya, (i) Economic Survey; and (ii) Statistical Abstract (Nairobi, Government Printer, Annual Issues up to 1976).

TABLE 5-3

Selected Prices and Price Indices in Kenya, 1955-1976

Year	*Sugar Price [Kshs. per kg]	Maize Price [Kshs. per kg]	Consumer Price Index: 1970=100	
			Food Only	Composite (All)
1976	4.50	7.22	160	160
1975	3.50	6.49	150	147
1974	2.40	4.14	124	124
1973	1.85	3.87	105	108
1972	1.85	3.80	100	100
1971	1.65	3.13	102	102
1970	1.55	2.77	100	100
1969	1.55	3.11	98	98
1968	1.54	3.20	99	98
1967	1.54	4.11	98	98
1966	1.54	3.61	97	96
1965	1.47	3.61	91	92
1964	1.47	3.00	90	91
1963	1.47	2.56	87	88
1962	1.36	3.94	85	86
1961	1.25	3.94	82	83
1960	1.30	3.56	81	81
1959	1.30	3.00	80	81
1958	1.28	3.89	81	81
1957	1.45	4.22	83	80
1956	1.30	3.91	81	78
1955	1.32	3.91	79	75

*The price considered is the retail price since the wholesale price records for the period before 1966 are not available.

SOURCES:
(1) Government of Kenya, (i) Statistical Abstract; and (ii) Economic Survey (Nairobi: Government Printer, Annual Issues up to 1976).
(2) East African Statistics Department, Quarterly Economics and Statistics Bulletin (EAHC, Nairobi, Back Issues to 1952).
(3) United Nations, Statistical Yearbook (New York, Various Issues up to 1978).
(4) Author's synthesis (calculations).

The price of sugar in Kenya has been regulated by the Government since sugar production was declared a special or scheduled crop in 1966.[1] In pricing, the Government takes into account the domestic cost of production, the supply and demand situation and the price movements in the world sugar market. To facilitate correlation analysis of domestic and world sugar prices, the ISO composite sugar price is taken as the relevant world sugar price.[2] Table 5-4 presents the ISO composite sugar price plus the population estimates, total disposable income, and per capita income for Kenya.[3] Various measures of national income could be used in the analysis; the relevant measure of national income used in the study is the disposable income.[4] The data presented in Table 5-4 suggests that there has been a relatively slow growth in per capita disposable income despite the apparently high growth in total disposable income, particularly after Kenya became a sovereign state in 1963. This trend can be attributed to the relatively fast growth in population (see Table 5-25).

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[1] As explained in Chapter I, the terms "special or scheduled crop" refer to any agricultural commodity in Kenya whose pricing or marketing is regulated by the Government.

[2] The ISO composite price was mentioned in an earlier section. This price is usually expressed in U.S. cents per pound, f.o.b. (or f.a.s.) Cuba or the Caribbean ports.

[3] Basically, the population figures are estimates since official population censuses have been held once a decade, the latest census having been held late in 1979.

[4] Examples include gross domestic product (GDP), gross national product (GNP), and various measures derived from GDP or GNP, such as total disposable income.

TABLE 5-4

International Sugar Price* and Kenya's Disposable Income and Population Estimates, 1955-1976

Year	International Sugar Price* (U.S. ¢ per lb.)	Kenya		
		Population Estimate (million)	Total Disposable Income (K£ million)	Per Capita Disposable Income (K£)
1976	11.50	13.85	1378.6	99.54
1975	20.44	13.40	1127.5	84.14
1974	29.66	12.91	982.7	76.12
1973	9.45	12.48	792.8	63.53
1972	7.27	12.07	709.4	58.77
1971	4.50	11.67	636.9	54.58
1970	3.68	11.23	560.8	49.94
1969	3.20	10.88	510.5	46.92
1968	1.90	10.48	469.6	44.81
1967	1.87	10.12	424.5	41.95
1966	1.76	9.78	403.8	41.27
1965	2.03	9.37	354.8	37.87
1964	5.72	9.10	358.6	39.41
1963	8.29	8.85	259.0	29.27
1962	2.78	8.60	244.0	28.37
1961	3.49	8.35	225.0	26.95
1960	3.14	8.12	226.0	27.83
1959	2.97	7.14	215.0	30.11
1958	3.50	6.95	208.0	29.93
1957	5.16	6.77	205.9	30.41
1956	3.47	6.59	193.4	29.35
1955	3.24	6.42	181.1	28.21

*As discussed elsewhere, the ISO composite sugar price is used to represent the free world market price of sugar, and is expressed in U.S. cents per pound, f.o.b. Caribbean ports.

SOURCES: (1) FAO, Commodity Review and Outlook (Rome: FAO, Various Issues up to 1978).
(2) UN, Demographic Yearbook (New York: UN Statistical Office, Various Issues up to 1978).
(3) Government of Kenya, Statistical Abstract (Nairobi: Government Printer, Various Issues up to 1976).

There has been a steady growth in consumption of sugar in Kenya over the last two decades. Production of sugar has also been increasing during the same period. However, domestic production level still falls below the total domestic requirements for sugar so that some imports of sugar still have to be made. Table 5-5 presents the various annual quantities of sugar consumption, imports and stocks in Kenya over the last two decades. The Government policy has been to maintain sugar imports to levels slightly higher than what is needed to satisfy total domestic requirements, the objective being to build up some stocks that could be used in the face of emergency situations. The sugar consumption, imports and stocks data indicate that there have been significant reductions in the proportion of sugar imports to total sugar consumption in Kenya over the sample years. Generally, the state trading corporation (KNTC) offers for sale in the domestic market only the quantity of sugar that is deemed adequate for the perceived demand. Stocks remain in the custody of KNTC and are not released unless there are acute sugar shortages in the country.

The expression and presentation of data in terms of an index relative to a specified base year or period facilitates identification of annual or seasonal movements. Besides, the analyses based on such indexed data offer results that are easy to compare or contrast directly. Hence the data were first expressed in terms of indices, with 1970 as the base year, wherever applicable, before being used in the desired analyses. The data indices can be found in the Appendix to the thesis.

The general data treatments involved the use of regression analysis in the determination of the structural coefficients of the various estimating models. Other treatments included correlation

TABLE 5-5

Consumption, Imports and Stocks of Sugar in Kenya, 1955-1976

(Thousand Metric Tons)

Year	Consumption	Imports	Stocks
1976	248	50	21
1975	235	50	29
1974	225	80	34
1973	217	76	16
1972	195	114	19
1971	180	59	8
1970	158	38	5
1969	142	27	..
1968	132	51	..
1967	121	61	..
1966	121	85	..
1965	112	83	..
1964	105	70	..
1963	98	60	..
1962	100	67	..
1961	93	60	..
1960	88	58	..
1959	78	50	..
1958	71	43	..
1957	69	49	..
1956	65	45	..
1955	55	38	..

.. The two dots imply that records of stocks are not available.

SOURCES: (1) Government of Kenya, (i) Statistical Abstract: and (ii) Economic Survey (Nairobi: Government Printer, Various Annual Issues up to 1976).

(2) Ministry of Agriculture, Economic Review of Agriculture, Vol. 7, No. 1, January-March, 1975 (Nairobi, Kenya).

coefficient analysis, price spreads analysis, and the tests of statistical significance for the results from the various analyses. The review of the analytic techniques was presented in the previous chapter; the specific data treatments and the applications of the analytic techniques will be presented in the ensuing paragraphs under relevant sections.

The Analysis, Evaluations and Applications of the Analytic Results

Introduction

This section of the chapter examines and discusses: (i) the general behaviour of the sugar market in Kenya in terms of marketing practices and prices; (ii) the analysis in terms of any econometric problems which were experienced and the remedial actions which were taken before obtaining the estimates of the models; (iii) the results of the estimate of the various analytic models; and (iv) the statistical significance and economic relevance of the various analytic results. The evaluation of the analytic results is followed by an application of these results in the assessment of the performance of the sugar industry and, subsequently, in the formulation of market improvement proposals for the industry.

Marketing and Sugar Price Spreads

Marketing and pricing of sugar in Kenya have been regulated by the Government since sugar was declared a scheduled crop in 1966. The control of the sugar market has been facilitated through granting of monopoly power over sugar trade to KNTC, a state trading corporation. The corporation ensures that sugar is sold at one price throughout the country by fixing the marketing margins. To facilitate sugar distribution, the state trading corporation operates strategically located depots in the major towns in the country and appoints dealers who act as its wholesalers in all major trading centres. The retailers obtain their sugar from the KNTC dealers and have to sell this sugar to the consumers at the Government announced price.[1]

Data on sugar marketing margins are hard to get. In view of the data scarcity or gathering problem, and given the fixed nature of sugar marketing margins, no analysis of the marketing margins is carried out in the study. However, the analysis of the sugar price spreads can be undertaken as a means to give the general trends in marketing margins. This approach facilitates an examination of the general behaviour of the market over time and is applied in this study.

In order to facilitate the analysis of movements in price and price-spreads for sugar using the available data, the following assumptions are made:

(i) Cane price represents the sugar producer price;

(ii) Price paid to sugar processors (ex-factory price) can be used as the proxy for the wholesale sugar price;

(iii) Sugar processing cost can be taken as a fixed proportion of the difference between the producer price and the wholesale price, so that the index of this difference can be used as a proxy for the wholesale price spread.

The retail price spread is calculated as the difference between the ex-factory price and the retail price of sugar.

Figures 5-1 through 5-5 illustrate the recent annual fluctuations of the producer, wholesale and retail prices of sugar in Kenya, including

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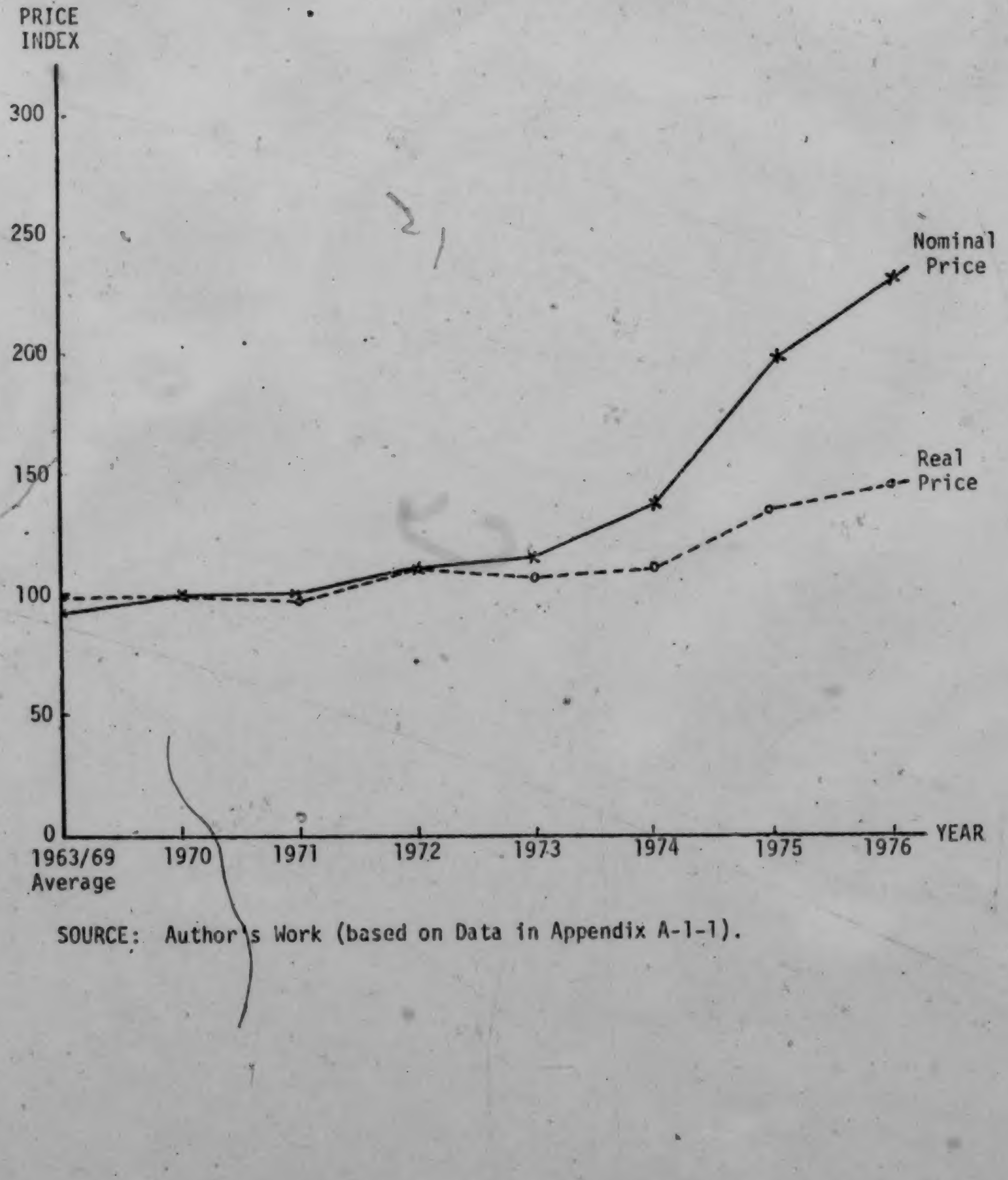
[1] A more detailed discussion of Sugar Marketing in Kenya is presented in Chapter III of the thesis.

FIGURE 5-1

Producer Price Movements for Sugar in Kenya, 1963/69-1976

(1970 = 100)

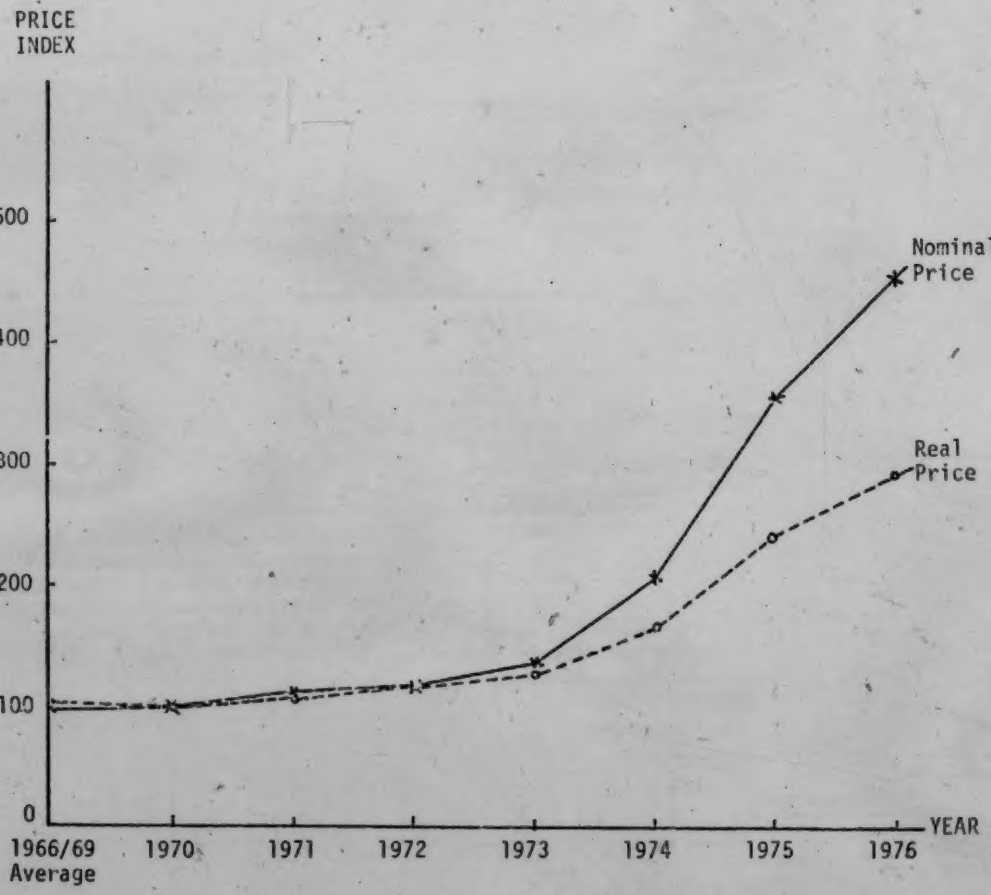


SOURCE: Author's Work (based on Data in Appendix A-1-1).

FIGURE 5-2

Wholesale Price Movements for Sugar in Kenya, 1966/69-1976

(1970 = 100)

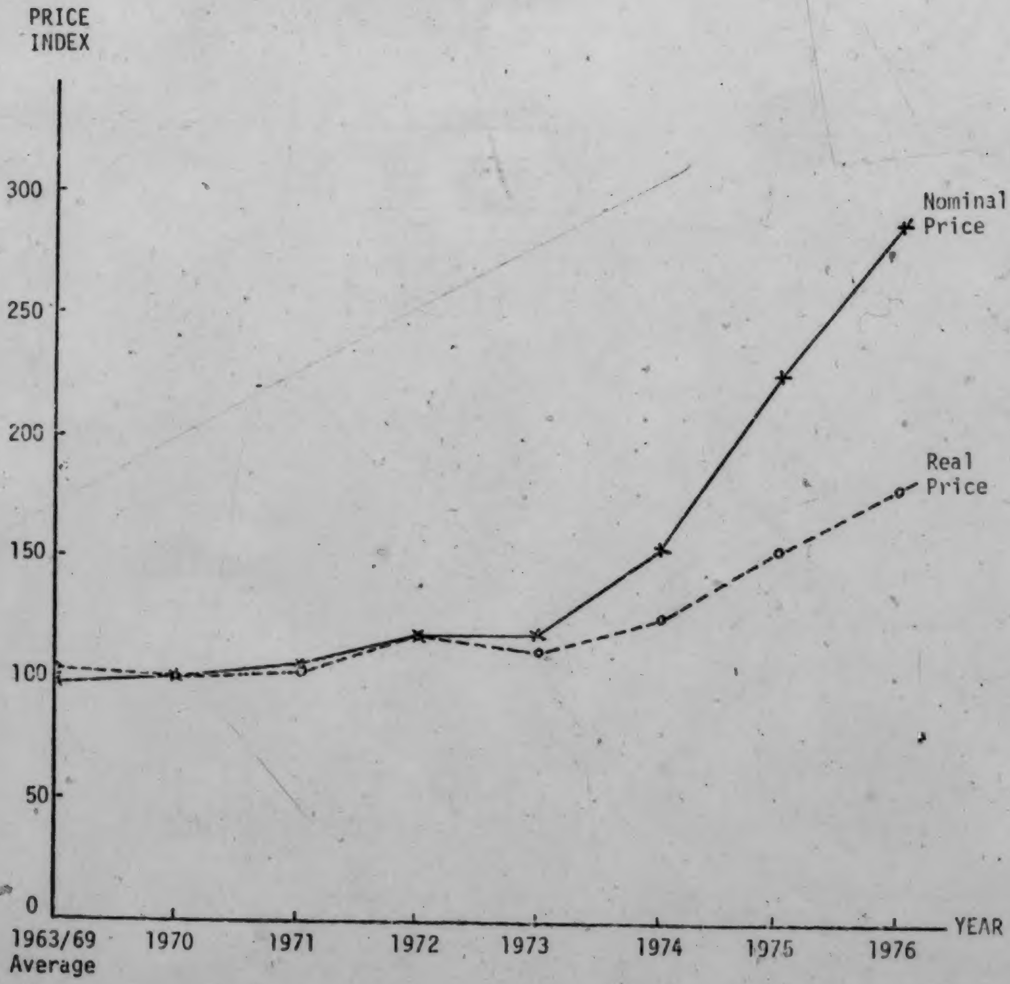


SOURCE: Author's Work (based on Data in Appendix A-1-1).

FIGURE 5-3

Retail Price Movements for Sugar in Kenya, 1963/69-1976

(1970 = 100)

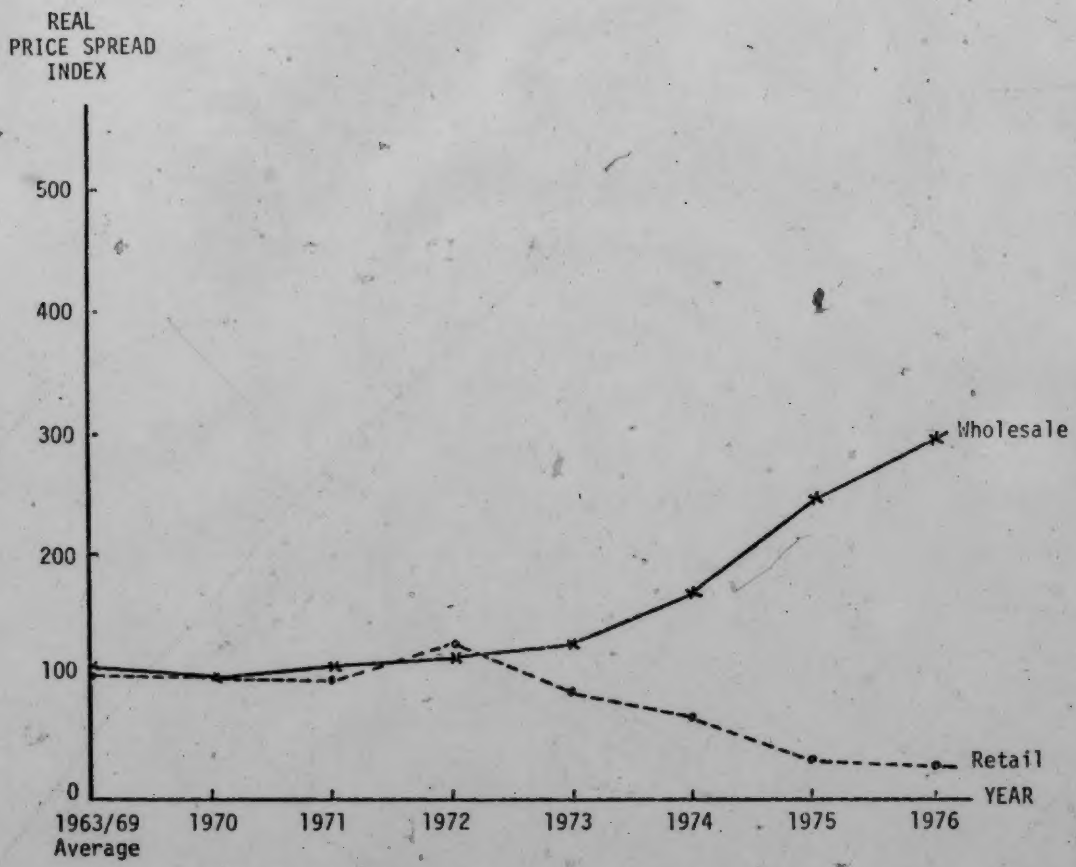


SOURCE: Author's Work (based on Data in Table A-1-1).

FIGURE 5-4

A Comparison of the Wholesale and Retail Sugar Price-Spreads Movements in Kenya, 1963/69-1976

(1970 = 100)

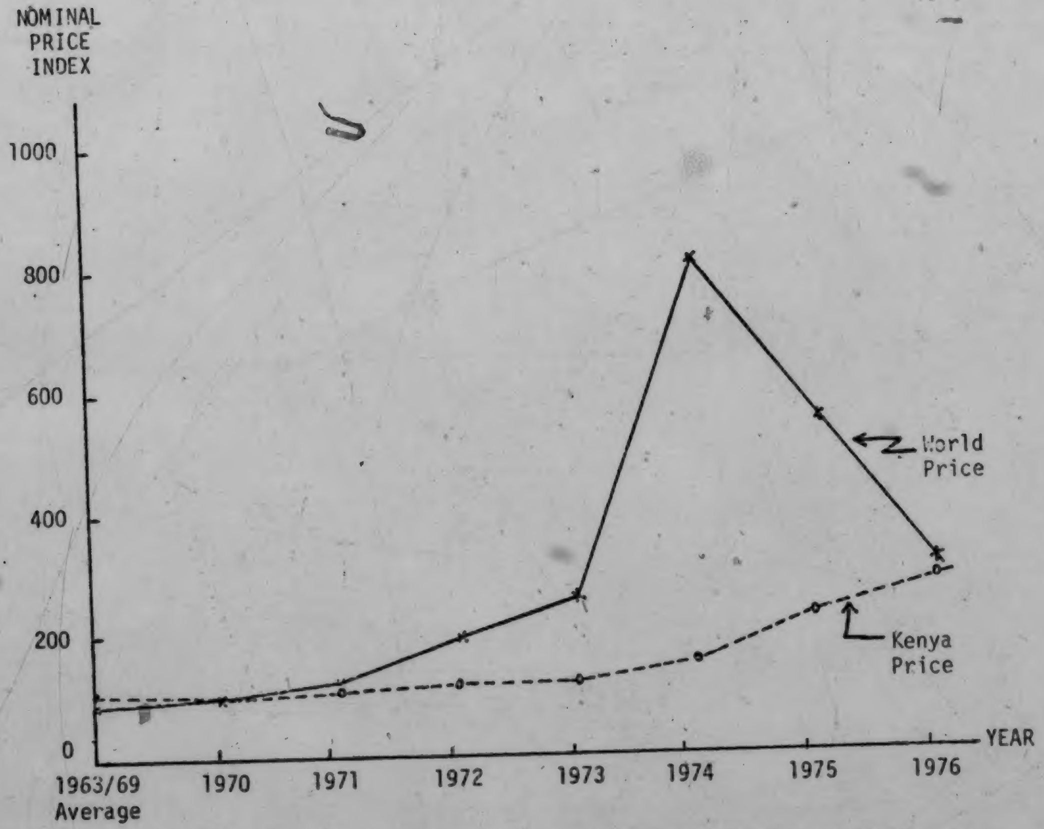


SOURCE: Author's Work (based on Data in Appendix A-1-2).

FIGURE 5-5

A Comparison of the Domestic (Kenya) and World* Sugar Price Movements, 1963/69-1976

(1970 = 100)



*Relevant World Market Sugar Price is the ISO composite price, which has been described elsewhere. The relevant domestic price is the retail price of sugar.

SOURCE: Author's Work (based on Data in Appendix A-3).

comparisons of annual fluctuations of (i) the domestic wholesale and retail price spreads and (ii) the domestic and world prices for sugar. Comparability is facilitated through the expression of the various structural variables in index forms, with 1970 as the base period.

The analysis of the trends in sugar prices shows that the producer, wholesale and retail prices had remained relatively stable for the period between 1969 and 1972. However, these prices experienced sharp increases after the end of 1972 (see Figures 5-1, 5-2 and 5-3). The general trend for the price of sugar in Kenya is seen to correspond with or follow closely the general trend for the world sugar price (see Figure 5-5). This trend is also evidenced by the fact that the correlation coefficient between the Kenyan sugar price and the world sugar price is about 0.62. Further, a simple regression analysis in which the Kenyan sugar price is expressed as a linear function of the world sugar price shows that the structural coefficient of the implied linear model is statistically significant at 1 percent level.[1] In spite of the high level of correlation between the Kenyan and the world sugar price, the price of sugar in Kenya has been rising more steadily when examined against the background of the high fluctuations in the world market price for sugar. The domestic price is also seen to have been sticky in a downward direction.

The analysis of the trends in price spreads shows that both wholesale and retail price spreads had followed the same general trend as the producer, wholesale and retail prices of sugar up to 1972. However, the wholesale price spread continued to follow the general trend in price increases while the retail price spread started to decline steadily after the end of 1972 (see Figure 5-4). The result of these general movements in the wholesale and retail price spreads is that the gap between the wholesale and retail prices of sugar in Kenya [illegible]s been narrowing steadily over the last ten years.

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[1] These inferences are based on the results of correlation and regression analyses which were carried out by the author. As explained elsewhere, the relevant world sugar price used in the analyses is the ISO composite sugar price.

Estimation of the Analytic Models

The choice of the types of analytic models and their nature of specifications is an important step in empirical analysis. Such a choice should be based on available information and the relevance of the results which are associated with the preliminary tests or applications of alternative models. The general linear model was chosen as the basis for the analytic models used in this study. Two alternative specifications of this general linear model were examined. The first one was based on the assumption of a linear relationship between the actual numerical values of the dependent and independent variables, while the second one was based on the assumption of a linear relationship between the logarithms of the numerical values of the dependent and independent variables in the model. The model based on the first type of specification will be referred to as the DLM (i.e., Direct Linear Model) while the model based on the second type of specification will be referred to as the LLM (i.e, Logarithmic Linear Model).

Estimates of the structural parameters of the analytic models are obtained through the application of the least squares estimation techniques. Assessments and evaluations of results based on different estimation procedures for different types of models are done in order to determine the models that adequately describe the structure of the sugar industry in Kenya. Such assessment and evaluation procedures involve the application of statistical methods. To be specific, the analytic models are subjected to scanning techniques or tests in order to detect the presence and severity of the econometric problems that could render the estimates unreliable, depending on the model estimation methods used. The estimates of the structural parameters of the models are then subjected to tests of statistical significance in order to assess their validity and reliability.

The presence and severity of individual econometric problems are assessed by applying appropriate scanning techniques or tests. The presence of serial correlation would make ordinary least squares (OLS) estimates inefficient,[1] though not biased; the same result would apply if heteroscedasticity were present. On the other hand, the presence of multicollinearity would make the estimate of individual structural coefficients of the models virtually impossible. Inefficiency of estimators arises from high variances for the estimators and is thus a problem that will arise if any of the econometric problems were present.[2]

A General Overview on Estimation Problems

Preliminary tests of the results based on the applications of the two alternative models, i.e., the Direct Linear Model (DLM) and Logarithmic

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[1] The terms "inefficient estimates" refer to the fact that the desirable property of "best" (i.e., "minimum variance") for OLS estimates is violated (see the introduction of Appendix A-5).

[2] A detailed discussion of the various scanning techniques or tests for the presence and severity of individual econometric problems can be found in the Appendix A-5. Individual estimating models will be introduced briefly under the relevant sections before the results of the model estimates are presented and discussed.

Linear Model (LLM), showed that both models gave statistically comparable and economically valid estimates. However, the DLM estimates were statistically significant at slightly higher levels, with some coefficients being slightly greater than those associated with the LLM. Hence, the DLM specifications are used in the ensuing analyses.[1]

The Goldfeld and Quandt tests and Spearman's rank correlation coefficient tests indicated that heteroscedasticity was not a problem. Durbin-Watson d-statistic and h-tests indicated that serial correlation was an isolated problem. Farrar-Glauber tests indicated that multicollinearity was the econometric problem that was frequently present.[2] Therefore, methods to facilitate model estimation in the presence of multicollinearity had to be devised and applied in a number of cases. The Cochrane-Orcutt iterative technique was used as a remedial measure for autocorrelation before obtaining the least square estimates of the model wherever tests for autocorrelation were positive.

The following are some general observations that are made from the experiences with empirical estimation of the models for supply and demand analysis using the conventional lagged supply-estimating model and the classical demand-estimating model:

(i) The estimates gave highly significant R-squared values and insignificant structural coefficients even at 10 percent level of significance when nominal data were used;

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[1] Such tests included the t-statistic tests for the significance of the estimated structural coefficients and the F-statistic tests for the goodness of fit of the estimated regression lines.

[2] See footnote No. 2 on the previous page.

(ii) When these nominal data were deflated with the consumer price index (CPI), the estimates did not improve: the R-squared values continued to be highly significant while the estimates of structural coefficients remained insignificant at the 10 percent level, some estimates being inconsistent with theory in terms of expected signs for the coefficients.

The above observations are consistent with what one may expect from model estimation when multicollinearity is present.[1] The inherent problem of multicollinearity became more severe when the data were deflated with the CPI. For this reason, nominal data are used in all of the model estimations and methods of estimation in the presence of multicollinearity had to be devised and applied before obtaining the least square estimates of the structural coefficients of the models. One may wish to obtain model estimates that are based on real magnitudes of the economic variables such as price and income, yet the presence of multicollinearity may necessitate the use of nominal variables. A suggested approach for obtaining estimates based on real magnitudes under such circumstances is the deflation of individual estimates of the structural coefficients of the models that one is interested in, with the average of the consumer price indices for the sample period after obtaining the estimates based on nominal data.

The Results of Supply Response Analysis

Cane production is an integral aspect of sugar production in Kenya. The Government sugar policy that was initiated in 1966 has been geared toward maintaining a cane price that will be an incentive toward increased cane production. Since the amount of sugar produced domestically is a constant proportion of the amount of cane produced and delivered to the processing mills, the analysis of sugar supply response was done in terms of examining the responsiveness of domestic production of both cane and sugar to changes in the values of the variables that normally influence the level of supply of agricultural products.

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[1] See, for example, D. Orr, op. cit., pp. 54-58.

The price P_t of cane or sugar, price index S_t for competitive produce, index W_t for weather or climatic condition, and index T for the state of technology were identified as the main explanatory variables in a model for estimating the supply function for cane or sugar at a specified time period. Hence the relevant model can be specified as:

$$Q_t^S = b_0 + b_1 Q_{t-1}^S + b_2 P_{t-1} + b_3 S_{t-1} + b_4 W_t + b_5 T + V_t \qquad (5\text{-}1)$$

where Q_t^S, for t = 1, 2, ..., n, are the observed levels of production and the other variables are as defined previously, following the notations of equation (4-8) in Chapter IV. The individual and joint effects of the various independent variables on the dependent variable could be examined through the stepwise regression technique.

Maize was shown to be the major competitive produce relative to cane and sugar production in Kenya (see Chapter III). Hence, a price index based on maize prices was constructed and used as a proxy for S_t in the estimating model. The amount of rainfall received in the cane-producing zones is the major weather variable influencing the supply of cane. Hence, an average rainfall index for the three main cane zones was used as a proxy for W_t, while a time trend factor was used as a proxy for T in the estimating model.

The use of stepwise regression technique in the analysis of individual and joint effects of the various explanatory variables on the dependent variable in the model implies that one or more of the explanatory variables are omitted in turn from alternative estimates of the model. This technique could be used along with the Farrar-Glauber tests to determine the relevant explanatory variables for models in empirical analysis. However, Farrar-Glauber tests are primarily intended to detect the explanatory variables in a model that could be the source of severe multicollinearity.[1]

The other types of models used in the estimation of the cane and sugar supply functions in Kenya were the weighted prices model (WPM) and the dynamic supply adjustment model (DSAM). The derivations and descriptions of the two types of models are given in Chapter IV [see especially equations (4-9) and (4-10)], but the specification of the two models will be presented once again in a later section of this chapter.

Stepwise regression results based on the estimation of the cane supply function using the model specified in equation (5-1) are summarized in Table 5-6.

The notations in Table 5-6 will be used in subsequent presentations and will thus be explained. For every model estimated, the first row (designated "Estimate") gives the estimates of the underlying structural coefficients of the model. The bracketed S.E. row gives the the standard errors of the estimates, while the SL row gives the significance levels associated with the appropriate estimates. From the theory, SL lies between 0 and 1 (i.e., $0 \leq SL \leq 1$), the statistical interpretation being that the closer to zero the SL, the greater the

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[1] D. Orr, op. cit., pp. 57-58.

TABLE 5-6

Supply Relationships for Cane in Kenya, 1962-1976

Models: $Q_t^S = b_o + b_1 Q_{t-1}^S + b_2 P_{t-1} + b_3 S_{t-1} + b_4 W_t + b_5 T + V$

(Stepwise Regression Results, Lagged Prices Model [LPM])

Model Specification Number and Description	COEFFICIENTS						R^2	F
	b_o	b_1	b_2	b_3	b_4	b_5		
1: Estimate	0.60	0.23	-0.34	0.39	-0.58	5.95	0.93	22.48
(S.E.)	0.42	0.30	0.50	0.38	0.37	2.73	-	-
SL	0.19	0.47	0.52	0.33	0.15	0.06	0.00	0.00
2: Estimate	0.73	0.10	0.22	0.20	-0.36	n/i	0.91	23.40
(S.E.)	0.48	0.25	0.46	0.31	0.25		-	-
SL	0.17	0.69	0.64	0.53	0.18		0.00	0.00
3: Estimate	-0.19	0.11	0.26	-0.06	n/i	5.96	0.91	23.82
(S.E.)	0.16	0.33	0.41	0.30		3.23	-	-
SL	0.91	0.75	0.54	0.84		0.10	0.00	0.00
4: Estimate	0.22	0.08	0.62	-0.08	n/i	n/i	0.89	27.38
(S.E.)	0.34	0.26	0.39	0.26			-	-
SL	0.54	0.77	0.14	0.77			0.00	0.00
5: Estimate	0.18	0.12	0.53	n/i	n/i	n/i	0.89	44.70
(S.E.)	0.31	0.23	0.20				-	-
SL	0.57	0.60	0.02				0.00	0.00
6: Estimate	0.33	n/i	0.54	n/i	n/i	n/i	0.89	96.06
(S.E.)	0.32		0.19				-	-
SL	0.32		0.01				0.00	0.00

4

n/i = Variable Not Included in the Estimating Model.

SOURCE: Author's work.

significance of the estimate.[1] The R-squared and F values indicate the significance of the estimated regression lines.

In Table 5-6, the first regression result (i.e., Model Specification 1) gives the estimate of the completely specified model. At the 10 percent level of significance, the estimate of the complete model for cane supply gave insignificant estimators for the structural coefficients, except for the coefficient of the time trend factor, despite the highly significant R-squared value of 0.93. Although the R-squared values suggest that Model Specification 1 gave the best fit for the cane supply function, only the estimating models in which single explanatory variables were used gave significant structural coefficients at the 10 percent level. The results suggest that the presence of some multicollinearity may be the causal problem for statistical insignificance for the estimates. Hence, Farrar-Glauber tests for the independent variables that could be the source of multicollinearity were executed.

Results of the Farrar-Glauber tests indicated that the time trend factor (T), prices (P_t and S_t) and the explanatory lagged quantity (Q^s_{t-1}) were highly collinear. These results are consistent with inferences that could be made from an examination of the partial correlation coefficients (see Table 5-7).

Based on Farrar-Glauber tests, Q^s_{t-1} could be the source of severe multicollinearity. From the matrix of correlation coefficients, P_{t-1} and S_{t-1} are highly correlated and could also introduce multicollinearity, while W_t is the least correlated with any other variable. Hence W_t could

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[1] Percentage significance levels at which the estimated coefficients are evaluated for statistical significance will be given in all relevant discussion.

TABLE 5-7

Matrix of the Partial Correlation
Coefficients for the Variables in the
Cane Supply Estimating Model (LPM)

	Q^s_t	Q^s_{t-1}	P_{t-1}	S_{t-1}	W_t	T
Q^s_t	1.00					
Q^s_{t-1}	0.93	1.00				
P_{t-1}	0.80	0.75	1.00			
S_{t-1}	0.51	0.40	0.86	1.00		
W_t	-0.07	-0.09	-0.14	-0.12	1.00	
T	0.94	0.93	0.77	0.45	0.11	1.00

SOURCE: Author's Work.

be dropped from the model without significantly affecting the explanatory power of the model. Similarly, any of the variables Q^s_{t-1}, T, P_{t-1} and S_{t-1} could be omitted without significantly reducing the value of R-squared in view of their high partial correlation coefficients. On theoretical grounds, and given the purpose of the analysis, Q^s_{t-1} and P_{t-1} must appear in the estimating model, no matter what approach is taken to correct for multicollinearity.

There are a number of suggested approaches for model estimation in the presence of multicollinearity. The simplest approach could involve the deflation of all variables in the model by any of the independent variables that could be the cause of multicollinearity, or the omission of one of any pair of explanatory variables that are collinear from the estimating model. More sophisticated approaches could involve the pooling technique or the principal component analysis technique.[1]

Most of the available approaches to model estimation in the presence of multicollinearity result in the loss of some information that could be useful in the analysis. For instance, the statistically popular technique that involves principal components analysis implies that a large group of independent variables is expressed in terms of their orthogonal linear combinations, thus giving a smaller set of explanatory variables. The transformations involved in this technique result in explanatory variables that are difficult to interpret directly as observed economic variables. Other techniques, such as the pooling technique, have limitations since they require prior knowledge about some of the structural coefficients.[2] Hence an assertion that none of the available techniques can be used to eliminate multicollinearity completely without sacrificing some information appears to be justified. The best remedy for multicollinearity would be to seek more information, for instance through selection of a new sample or through increasing the size of the sample.[3] This remedy could not be applied in this study. Omission of one of any two explanatory variables in the model that are highly collinear is a common approach to model estimation in the presence of multicollinearity and is examined in the study.

Given the limitations of the available approaches to model estimation in the presence of multicollinearity and taking into account the size of the sample and the main purpose of the analysis, which is to obtain the price effect on production, the approach adopted in the estimation of the cane supply function was to omit some of the independent variables from the estimating model and examine if significant price coefficients could be obtained. Hence the estimating models for the cane supply function can now be specified as:

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[1] See, for instance, M. Dutta, op. cit., pp. 154-156; 235-239.

[2] Ibid., p. 154 and p. 156.

[3] D. Orr, op. cit., p. 258; and M. Dutta, op. cit., pp. 155-156.

$$\text{(i)}\quad Q_t^s = b_o + b_1 Q_{t-1}^s + b_2 P_{t-1} + V_t \qquad (5\text{-}2)$$

for the short-run supply function, so that:

$$b_1 = (1 - A)$$

where A is the adjustment parameter; in the long-run, A = 1 so that:

$$\text{(ii)}\quad Q_t^s = b_o + b_1 P_{t-1} + V_t \qquad (5\text{-}3)$$

is the long-run version of the supply-estimating model. The last two regression results in Table 5-6 give the estimates of equations (5-2) and (5-3). These are the estimates that will be used in further analytic work, particularly in the evaluation of the analysis.

The lack of a large sample was a major limitation for the types of models that could be used in the estimation of the cane supply function. A small sample imposes the problem of degrees of freedom as the number of structural coefficients of the model to be estimated is increased. For this reason, the available number of observations on the data related to sugar production was considered sufficient to facilitate the estimation of the sugar supply function using the DSAM and the weighted prices model.

Estimation of the sugar supply function using the conventional lagged prices recursive model resulted in problems similar to those experienced during the estimation of the cane supply function using the same type of model. Table 5-8 presents the stepwise regression results

TABLE 5-8

Supply Relationships for Sugar in Kenya, 1955-1976

Models: $Q_t^s = b_o + b_1Q_{t-1}^s + b_2P_{t-1} + b_3S_{t-1} + b_4W_t + b_5T + V_t$

(Stepwise Regression Results, Lagged Prices Model [LPM])

Model Specification Number and Description	COEFFICIENTS						R^2	F
	b_o	b_1	b_2	b_3	b_4	b_5		
1: Estimate	-0.17	0.63	-0.19	0.28	-0.12	0.03	0.95	58.13
(S.E.)	0.22	0.17	0.22	0.18	0.18	0.01	-	-
SL	0.43	0.00	0.41	0.14	0.54	0.02	0.00	0.00
2: Estimate	-0.28	0.71	-0.27	0.34		0.03	0.95	76.21
(S.E.)	0.13	0.14	0.20	0.16	n/i	0.01	-	-
SL	0.05	0.00	0.21	0.05		0.01	0.00	0.00
3: Estimate	-0.22	0.995	-0.14	0.22	0.13		0.93	51.95
(S.E.)	0.25	0.12	0.25	0.20	0.20	n/i	-	-
SL	0.39	0.00	0.59	0.29	0.54		0.00	0.00
4: Estimate	-0.09	0.96	-0.05	0.15			0.93	72.58
(S.E.)	0.14	0.13	0.23	0.18	n/i	n/i	-	-
SL	0.54	0.00	0.81	0.41			0.00	0.00
5: Estimate	-0.02	0.91	0.09				0.92	110.32
(S.E.)	0.12	0.11	0.15	n/i	n/i	n/i	-	-
SL	0.86	0.00	0.55				0.00	0.00
6: Estimate	1.73		0.14				0.92	213.92
(S.E.)	0.81	n/i	0.17	n/i	n/i	n/i	-	-
SL	0.05		0.42				0.00	0.00

n/i = Variables Not Included in the Estimating Model.

SOURCE: Author's Work.

based on the lagged prices recursive model.

The results given in Table 5-8 show that the estimation of the completely specified model, as described by equation (5-1), gave price-coefficient estimates that were inconsistent with theory expectations and statistically insignificant at 10 percent level. Another observation is the result that the omission of some explanatory variables from the estimating models did not substantially reduce the R-squared values. These results suggest that multicollinearity could be present, and this inference is supported by the results of partial correlation analysis for the various variables in the completely specified estimating model (see Table 5-9).

Based on the results of partial correlations analysis, the explanatory lagged dependent variable Q^s_{t-1}, the trend variable T and the price variable P_{t-1} could be suspected to be the source of multicollinearity. Therefore, a method of estimation in the presence of multicollinearity had to be devised.

Price coefficients are of major interest in economic analysis, yet the six results from stepwise regressions gave estimates of price coefficients that were statistically insignificant at the 10 percent level and inconsistent in terms of theory expectations (see Table 5-8). Given the importance of price coefficients in the analysis, omission of price variables from the estimating models on the grounds that prices and other variables are collinear would not be appropriate as a method of estimation in the presence of multicollinearity. Any transformation of original data or any other approaches that are designed to facilitate model estimation in the presence of multicollinearity should be designed such that the interpretations for the price coefficients from the estimates will not be ambiguous.

TABLE 5-9

Partial Correlation Coefficients Matrix for the Variables in the Sugar Supply Function Estimating Model (LPM)

	Q^s_t	Q^s_{t-1}	P_{t-1}	S_{t-1}	W_t	T
Q^s_t	1.00					
Q^s_{t-1}	0.96	1.00				
P_{t-1}	0.80	0.81	1.00			
S_{t-1}	0.39	0.35	0.69	1.00		
W_t	0.23	0.23	0.22	-0.18	1.00	
T	0.92	0.90	0.73	0.20	0.43	1.00

SOURCE: Author's Work.

The first attempt to estimate the sugar supply function in the presence of multicollinearity was carried out by omitting some variables from the estimating models. However, this procedure did not result in significant price coefficients (see Table 5-8) even at levels of significance as low as 10 percent. Weighting of price variables in the estimating model was perceived as a possible method of reducing the severity of multicollinearity. Such weighting should be based on theory and known biological characteristics of the produce whose prices are to be weighted. Consequently, a weighted prices model whose specification is:

$$Q^s_t = b_o + b_1Q^s_{t-1} + b_2P^*_t + b_3S^*_t + b_4W_t + b_5T + V_t \qquad (5\text{-}4)$$

where:

$$P_t^* = \frac{1}{12}P_t + \frac{2}{12}P_{t-1} + \frac{3}{12}P_{t-2} + \frac{3}{12}P_{t-3} + \frac{2}{12}P_{t-4} + \frac{1}{12}P_{t-5}$$

$$S_t^* = \frac{1}{4}S_t + \frac{3}{4}S_{t-1}$$

was used in the estimation of the supply function. The justification for the weighting and the lag structure, including the definition and description of the notations was given in Chapter IV [see especially equation (4-9)].

From theoretical considerations, the weighted prices model of equation (5-4) takes into account producers reactions to price changes over a relatively long period (covering the life cycle of the crop). Hence the model is likely to fit the description of a long-run supply estimating model more than that of a short-run type of estimating model. Table 5-10 gives the results of the estimate using the weighted prices model.

These results indicate that the estimates of the structural coefficients obtained through the use of the weighted prices model are significant at 10 percent level, except for the coefficient of the explanatory lagged variable Q_{t-1}^S, which is not significantly different from zero at that level of significance. The results suggest that the value of the adjustment parameter is close to unity, which suggests that the model gives an estimate of the long-run supply function. Hence the two specifications illustrated in Table 5-10 give relatively close estimates.

Another perceived method of estimation that might facilitate estimation in the presence of multicollinearity was to use the model in which the relevant explanatory variables are deflated with indices based on the anticipated annual changes in their levels. This approach suggests

TABLE 5-10

Sugar Supply Function, Kenya, 1955-1976

Models: $Q_t^s = b_o + b_1 Q_{t-1}^s + b_2 P_t^* + b_3 S_t^* + b_4 W_t + b_5 T + V_t$

(Weighted Prices Model, WPM)

Description	COEFFICIENTS b_o	b_1	b_2	b_3	b_4	b_5	R^2	F
Specification 1:								
Estimate	-0.81	-0.15	1.56	-0.55	-0.30	0.07	0.96	70.57
(S.E.)	0.42	0.22	0.75	0.25	0.13	0.03	-	-
SL	0.07	0.50	0.05	0.05	0.03	0.02	0.00	0.00
Specification 2:								
Estimate	-0.60		1.37	-0.48	-0.29	0.06	0.96	91.38
(S.E.)	0.31	n/i	0.63	0.22	0.12	0.03	-	-
SL	0.07		0.04	0.05	0.03	0.02	0.00	0.00

n/i = Variable Not Included in the Estimating Model.

SOURCE: Author's Work.

that previous levels of the variables are deflated with indices based on the current changes in the levels of the appropriate variables. This specification of the model is likely to reduce the degree of collinearity between the relevant explanatory variables in the model. The proposed model specification gives a model whose structure is:

$$Q_t^s = b_o + b_1 Q_{t-1}^s + b_2 \left(\frac{P_{t-1}}{PDEX}\right) + b_3 \left(\frac{S_{t-1}}{SDEX}\right) + b_4 \left(\frac{W_{t-1}}{WDEX}\right) + V_t \qquad (5\text{-}5)$$

The model of equation (5-5) is the model that was proposed as a dynamic supply adjustment model (DSAM) in equation (4-10) of Chapter IV.

The specification of DSAM incorporates effects of time changes directly in the explanatory variables so that the trend variable T, which was shown to be highly collinear with the other variables, does not appear as a separate explanatory variable. This step in specification in itself is seen as a likely means of reducing the problem of multicollinearity. The nature of DSAM specification also suggests that DSAM is likely to be more appropriate as a short-term supply estimating model since it incorporates year-to-year movements of the changes in the levels of the explanatory variables.

Table 5-11 gives the estimate of the sugar supply function based on DSAM specification as described in equation (5-5) and on two variants of this model, which are given as Specifications 2 and 3. The second and third specifications in the estimate of the DSAM are done in order to see what happens when the variables whose coefficients have been shown to be statistically insignificant at a specified level are not included in the estimating model.

The results given in Table 5-11 indicate that DSAM estimates gave price coefficients that were consistent with theory expectations and statistically significant at 10 percent level. The results also show that the omission of variables whose coefficients have been shown to be statistically insignificant at a specified level has an impact on the magnitudes and significance levels for the estimates of the coefficients of the remaining variables in the estimating model. The DSAM estimates also showed that the adjustment parameter is highly significant (i.e., statistically significant at the 1 percent level). This result shows that short-term supply adjustments based on price expectations have been statistically significant at the 1 percent level. In view of this high level of statistical significance for the adjustment parameter in relation to the significance levels for the other structural coefficients, DSAM

TABLE 5-11

Sugar Supply Function, Kenya, 1955-1976

Model: $Q_t^s = b_o + b_1 Q_{t-1}^s + b_2\left(\frac{P_{t-1}}{PDEX}\right) + b_3\left(\frac{S_{t-1}}{SDEX}\right) + b_4\left(\frac{W_{t-1}}{WDEX}\right) + V_t$

(Dynamic Supply Adjustment Model, DSAM)

Description	COEFFICIENTS					R^2	F
	b_o	b_1	b_2	b_3	b_4		
Specification 1:							
Estimate	0.02	0.94	0.26	-0.04	0.01	0.94	65.94
(S.E.)	0.06	0.07	0.13	0.02	0.01	-	-
SL	0.74	0.00	0.06	0.05	0.29	0.00	0.00
Specification 2:							
Estimate	0.04	0.92	0.20	-0.03	n/i	0.94	86.48
(S.E.)	0.06	0.07	0.12	0.01		-	-
SL	0.50	0.00	0.10	0.07		0.00	0.00
Specification 3:							
Estimate	n/i	0.96	0.21	-0.03	n/i	0.94	n/a
(S.E.)		0.45	0.11	0.02		-	
SL		0.00	0,08	0.06		0.00	

n/i = Variable Not Included in Estimating Models.

n/a = Not Available, since constant depressed.

SOURCE: Author's Work.

estimates with the lagged quantity explanatory variable excluded did not yield statistically significant estimates at the 10 percent level for the coefficients of the included explanatory variables. The results of Specification 1 in Table 5-11 are used in further analysis.[1]

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[1] The behavioural assumptions of the model (DSAM) still need some further evaluation or tests, although the model appears to have given some results that are consistent with theory expectations.

Some Concluding Remarks on the Results of Supply Response Analysis

The apparent lack of previous quantitative evaluations of the responsiveness of cane or sugar supply to economic incentives led to the conception of this analysis.[1] In this study, cane and sugar production in Kenya have been shown to be sensitive to economic incentives: changes in cane and sugar prices have had statistically significant impacts on the levels of the supply of cane and sugar (see especially the results of Model Specifications 5 and 6 in Table 5-6 and the results in Tables 5-10 and 5-11). An important observation that can be made from the experiences with model estimation is the fact that the results are sensitive to model specifications and the estimation methods. The conventional lagged prices model of supply analysis [see equation (5-1)] was shown to be unsatisfactory as a supply-estimating model in the presence of multicollinearity: this problem was circumvented by using a weighted prices model [see equation (5-4)] and a more integrative dynamic supply adjustment model, DSAM [see equation (5-5)]. The latter two supply estimating models gave plausible results and are recommended as facile supply analytic tools.

In view of the above experiences, one can suggest that all feasible model specifications and estimation methods should be examined in empirical analysis before one succumbs to conclusions based on a particular model specification and estimation method, particularly if such conclusions contradict theory expectations.

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[1] See the review of relevant literature in Chapter III of the thesis.

The Results of Demand Analysis

The purpose was to estimate a sugar demand function for Kenya, using both the dynamic version of the classic model of demand analysis and the state adjustment model (SAM). The SAM is a dynamic model of demand analysis which was first proposed and used by Houthakker and Taylor in 1970 [full description can be found in Chapter IV--see especially equations (4-14) through (4-24)].

The dynamic version of the classical demand model can be specified either as:

$$Q_t^d = a_o + a_1P_t + a_2Y_t + a_3N_t + a_4T + U_t \qquad (5\text{-}6)$$

in aggregate terms, or as:

$$q_t^d = a_o + a_1P_t + a_2y_t + a_3T + U_t \qquad (5\text{-}7)$$

in per capita (i.e., individual) terms. The notations are as given in the derivation of equations (4-12) through (4-24) in Chapter IV, the only addition being N_t variable for total consuming units (i.e., population variable) in equation (5-6). The SAM is usually specified on a per capita basis, and may be expressed as:

$$q_t^d = A_o + A_1q_{t-1}^d + A_2y_{t-1} + A_3\Delta y_t + A_4\Delta P_t + A_5P_{t-1} + U_t \qquad (5\text{-}8)$$

for the short-term adjustment model, or as:

$$q_t^d = c_o + c_1y_t + c_2P_t + U_t \qquad (5\text{-}9)$$

for the long-term adjustment model.

As observed in an earlier section of the analysis, multicollinearity and, to some extent, serial correlation are the econometric problems that are most likely to occur in multiregression analysis when using time series data. The latter problem is easily corrected for through the use of Cochrane-Orcutt iterative technique, and this was done in all estimates where tests suggested the presence of autocorrelation. Table 5-12 gives the estimate of equation (5-6) using the Cochrane-Orcutt iterative technique.

TABLE 5-12

Dynamic Aggregate Sugar Demand
Function, Kenya, 1955-1976

Model: $Q_t^d = a_o + a_1P_t + A_2Y_t + a_3N_t + a_4T + U_t$

Description	COEFFICIENTS					R^2	F
	a_o	a_1	a_2	a_3	a_4		
Estimate	-0.40	-0.09	0.19	0.57	0.05	0.99	605.03
(S.E.)	0.40	0.06	0.13	0.55	0.03	-	-
SL	0.33	0.20	0.18	0.31	0.16	0.00	0.00

SOURCE: Author's Work.

The results in Table 5-12 indicate that the estimate of the aggregate demand function for sugar (using the classical demand model) gave structural coefficients that were statistically insignificant at the 10 percent level and a highly significant R-squared value. These results suggest that multicollinearity may be present, a possibility that is supported by the results of partial correlation analysis which indicate that all the variables are highly correlated (see Table 5-13), with N_t and T being almost perfectly collinear. Based on the results of Farrar-Glauber tests, N_t and T could be the major source of severe multicollinearity. Hence one of these variables could be omitted in the estimating model. On theoretical grounds, N_t should appear in an aggregate model, while T should be accounted for in a dynamic model. In order to satisfy both requirements, a per capita demand model whereby N_t is accounted for

TABLE 5-13

Partial Correlation Coefficients Matrix
for the Variables in the Sugar Demand Function
Estimating Model

	Q_t^d	P_t	Y_t	N_t	T
Q_t^d	1.00				
P_t	0.80	1.00			
Y_t	0.96	0.92	1.00		
N_t	0.98	0.75	0.93	1.00	
T	0.97	0.72	0.90	0.996	1.00

SOURCE: Author's Work.

in per capita consumption and per capita income variables was considered the relevant analytic model. However, a static aggregate demand model was also estimated in order to facilitate comparisons of various model specifications.

Table 5-14 gives the estimate of the aggregate demand function in which T has been omitted. This is then the static aggregate demand function. A comparison of the results in Tables 5-12 and 5-14 shows that omission of T did not affect the goodness of fit of the regression line. However, this did result in statistically significant estimates of the structural coefficients of the model at the 10 percent level, thus confirming the role of T in introducing multicollinearity.

Table 5-15 gives the estimates of the individual demand functions.

TABLE 5-14

Static Aggregate Demand Function, Kenya, 1955-1976

Model: $Q_t^d = a_o + a_1P_t + a_2Y_t + a_3N_t + U_t$

Description	COEFFICIENTS				R^2	F
	a_o	a_1	a_2	2_3		
Estimate	-0.28	-0.12	0.34	1.11	0.99	774.85
(S.E.)	0.23	0.07	0.12	0.30	-	-
SL	0.25	0.07	0.01	0.00	0.00	0.00

SOURCE: Author's Work.

TABLE 5-15

Per Capita Sugar Demand Function, Kenya, 1955-1976

Model: $q_t^d = a_o + a_1P_t + a_2y_t + a_3T + U_t$

Description	COEFFICIENTS				R^2	F
	a_o	a_1	a_2	a_3		
Specification 1:						
Estimate	0.57	-0.08	0.27	0.02	0.97	205.48
(S.E.)	0.07	0.06	0.13	0.01	-	-
SL	0.00	0.15	0.06	0.06	0.00	0.00
Specification 2:						
Estimate	0.93	-0.08	0.29		0.97	283.89
(S.E.)	0.13	0.06	0.11	n/i	-	-
SL	0.00	0.18	0.02		0.00	0.00

n/i = Variable Not Included in the Estimating Model

SOURCE: Author's Work.

Table 5-15 indicates that the omission of T in the per capita model did not significantly influence the estimates. The deflation of quantity and income variables by Y_t may have increased the degree of collinearity to some extent. In view of the suspected existence of some multicollinearity, and given the sample size, the obtained estimates of price coefficients at 15 and 18 percent significance levels for the two specifications could be considered acceptable for further analytical evaluations.

Another method that could be used in the estimation of a model in the presence of multicollinearity is to deflate every other variable in the model by a variable whose coefficient is of interest. In this case, the approach would be to use the price variable as a deflator, so that the per capita demand estimating model becomes:

$$\left(\frac{q_t^d}{P_t}\right) = \left(\frac{a_o}{P_t}\right) + a_1 + a_2\left(\frac{y_t}{P_t}\right) + a_3\left(\frac{T}{P_t}\right) + \left(\frac{U_t}{P_t}\right) \qquad (5\text{-}10)$$

Note that equation (5-10) is mathematically identical to equation (5-7) The intercept obtained for equation (5-10) is now seen to be the price coefficient.

Since the term (a_o/P_t) in equation (5-10) is of little economic relevance, the actual model estimated in the study had this term omitted. Table 5-16 gives the estimate of this price-deflated per capita demand function for sugar. The deflation of the per capita demand model by price variable thus resulted in significant structural coefficients at the 5 percent level for all the variables in the model. Hence the results in Table 5-16 will be used in further analytical evaluations.

TABLE 5-16

Price-Deflated Per Capita Sugar Demand
Function for Kenya, 1955-1976

Model: $\left(\frac{q_t^d}{P_t}\right) = c_o + c_1\left(\frac{y_t}{P_t}\right) + c_2\left(\frac{T}{P_t}\right) + \left(\frac{U_t}{P_t}\right)$

Description	COEFFICIENTS c_o	c_1	c_2	R^2	F
Estimate	-0.65	0.31	6.05	0.90	73.62
(S.E.)	0.26	0.13	1.12	-	-
SL	0.02	0.04	0.00	0.00	0.00

SOURCE: Author's Work.

The other type of demand system to be estimated was the state adjustment model (SAM), as specified in equations (5-8) and (5-9). Table 5-17 gives the estimate of the short-run state adjustment model.

TABLE 5-17

Per Capita Sugar Demand Function, Kenya, 1955-1976

Model: $q_t^d = A_o + A_1 q_{t-1}^d + A_2 y_{t-1} + A_3 y_t + A_4 P_t + A_5 P_{t-1} + U_t$

(Short-run SAM)

Description	COEFFICIENTS A_o	A_1	A_2	A_3	A_4	A_5	R^2	F
Estimate	0.07	0.76	0.16	0.01	-0.12	-0.02	0.98	136.57
(S.E.)	0.10	0.16	0.10	0.01	0.05	0.06	-	-
SL	0.49	0.00	0.13	0.34	0.03	0.76	0.00	0.00

SOURCE: Author's Work.

The results from the estimate of the short-run state adjustment model suggest that short-term adjustments to price changes have been highly significant (i.e., significant at the 1 percent level). The estimate represents a good fit, the estimated structural coefficients being consistent in terms of expected signs. The statistically insignificant coefficients at the 10 percent level for lagged price variable and changes in income suggest three likely ramifications: (i) that the perverse incidence of multicollinearity, which had been shown to plague other models, was still affecting the estimates of the short-run SAM; (ii) that the degree of habit-formation, which constitutes the microfoundation of the state adjustment model, is not statistically significant at the 10 percent level in the case of sugar; and (iii) the annual data used in the estimate may not be the appropriate type of data for short-run adjustment models in the case of sugar.

Based on the results from partial correlations analysis for the determinants of the short-term adjustments in sugar consumption, multicollinearity could be a problem (see Table 5-18). The high levels of partial correlation between the variables in the short-run SAM made the estimation of the linear model difficult. Since one cannot devise a method of estimation of the short-run SAM in the presence of multicollinearity without changing the structure of the model, it was considered appropriate to leave the estimates as presented in Table 5-17.

On empirical grounds, one could argue that the consumption of tea, with sugar as the sweetener, has become more widespread in average households in Kenya during the last decade and this could have influenced the degree of habit-formation in sugar consumption during the same period.

TABLE 5-18

Partial Correlation Coefficients of the Variables of the State Adjustment Model

	q_t^d	q_{t-1}^d	P_{t-1}	P_t	y_{t-1}	y_t
q_t^d	1.00					
q_{t-1}^d	0.96	1.00				
P_{t-1}	0.76	0.73	1.00			
P_t	0.68	0.67	0.85	1.00		
y_{t-1}	0.93	0.89	0.89	0.86	1.00	
y_t	0.71	0.65	0.79	0.74	0.77	1.00

SOURCE: Author's Work.

Hence the results obtained for the short-run SAM estimate cannot be justified on the grounds of a low degree of habit-formation for sugar consumption in Kenya. The third possibility that annual data are not appropriate in the analysis of short-term adjustments in sugar consumption could be the relevant explanation for the results obtained, especially if multicollinearity was not severe. If this were the case, then the estimate of the long-run SAM would likely give statistically significant structural coefficients at the 10 percent or even higher levels of significance.

Table 5-19 gives the estimate of the long-run state adjustment model, as specified in equation (5-9).

TABLE 5-19

Long-run Per Capita Sugar Demand
Function, Kenya, 1955-1976

Model: $q_t^d = c_o + c_1 y_t + a_2 P_t + U_t$

(Long-run SAM)

Description	COEFFICIENTS			R^2	F
	c_o	c_1	c_2		
Estimate	0.93	0.29	-0.08	0.97	283.89
(S.E.)	0.13	0.11	0.06	-	-
SL	0.00	0.02	0.18	0.00	0.00

SOURCE: Author's Work.

The results obtained from the estimate of the long-run SAM gave coefficients that were significant at higher levels than those for the short-run SAM estimate. The significance level for the price coefficient was still lower than 10 percent in the long-run estimate. These results suggest that multicollinearity was still affecting the estimates to some extent. The latter inference is based on the observed high partial correlation coefficient between P_t and y_t (see Table 5-18). Hence the inference that annual data may not be the appropriate ones for the analysis of consumption of sugar using the state adjustment models still looks plausible.

Given the size of the available sample and the possibility of the existence of multicollinearity, the results of the long-run SAM estimate (Table 5-19) are considered acceptable for further analytical applications. A further observation is the result that the long-run SAM estimate is the same as the static estimate of the classical demand-estimating model (see Table 5-15). However, there is an inherent difference in the appreciation and interpretation of the results based on the two types of model, which is implicit in the derivation of the long-run SAM [see equations (4-22) through (4-24)].

Some Concluding Remarks on the Results of Demand Analysis

A number of model specifications and estimation methods were used in order to obtain a result that could be considered as adequately descriptive of the sugar consumption pattern in Kenya. The impetus of the analysis was borne out of the author's discontent with previous studies on sugar consumption in Kenya that have concluded that only a simple trend model has been able to give a good fit to the consumption data: price coefficients in all such studies, and price and income coefficients in some studies, have been found to be statistically insignificant at acceptable levels of significance. Such conclusions contradict theory expectations and require further appraisals.

This study has demonstrated that consumption of sugar in Kenya is sensitive to both price and income changes: some model specifications have given estimates of price coefficients that are statistically significant at 10 percent or even higher levels of significance. The results also illustrate the importance of proper model specification and estimation methods: the results obtained in the previous studies are of doubtful reliability since no treatment of econometric problems appears to have been given.[1]

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[1] Examples of the previous studies on the sugar industry in Kenya can be found in the section on the review of literature in Chapter III.

Simultaneous Equations Modelling for the Sugar Industry

The results presented and discussed in the preceding paragraphs, i.e., in Tables 5-6 through 5-19, are based on the assumption of recursively determined supply and demand functions. These results were obtained through the application of the Cochrane-Orcutt iterative technique before obtaining least square estimates wherever the tests of autocorrelation were positive. Basically, the generalized least squares estimation technique (GLS) was used in the estimation of the various models. The purpose of the ensuing analysis is the generation of estimates for supply and demand functions based on the assumption of simultaneously determined equation models. The results of such estimates are then compared with those from recursively determined models.

Under a general market equilibrium condition, supply and demand functions are said to be determined simultaneously. Alternatively, the observed market price is said to be determined simultaneously by the forces of supply and demand. Under such conditions, the instrumental variable technique (IVT) could be used to estimate the supply and demand functions without introducing the simultaneous equations bias in the estimates. Hence the IVT estimates of the sugar supply and demand functions in Kenya were obtained in order to facilitate market analysis under two different assumptions about the sugar price formation.

Alternative assumptions about the sugar price formation in Kenya were examined in order to assess the role of the Government involvement in market regulation. The first alternative assumption was that the Government involvement in market regulation has had a statistically significant impact on the market price for sugar in Kenya. The second alternative was that the Government involvement in sugar pricing could be likened to the role of an auctioneer in price formation. If the first assumption were true, then the functions determined under the assumption that prices are predetermined (exogenous) would be significantly different from those determined under the assumption that prices are endogenous. If the first assumption were false, then the second assumption would be true.

The following is the general specification of the simultaneous equations model of demand and supply of sugar in Kenya that was estimated:

(i) Supply Function:

$$Q_t^s = f(P_t, S_t, W_t)$$

(ii) Demand Function:

$$Q_t^d = g(P_t, Y_t, N_t, T)$$

(iii) Market Equilibrium Condition:

$$Q_t^s = Q_t^d = \bar{Q} \qquad (5\text{-}11)$$

where f and g denote the functional relationships and all the other notations are as used before. Variables S_t, W_t, T, Y_t and N_t are predetermined so that the two functions are identified, i.e., they can be determined empirically.

Table 5-20 gives the results of the estimate of the supply function, based on equation (i) of the model (5-11). These results show that the estimating model gave a good fit. However, the estimated coefficients are not significant at the 10 percent levels. This result can be attributed to the presence of some multicollinearity, as determined in earlier tests. Given the small sample size, one cannot devise means to overcome the problem of multicollinearity without sacrificing some information that is needed to

TABLE 5-20

Sugar Supply Function, Kenya, 1955-1976

Model: $Q_t^s = b_o + b_1 Q_{t-1}^s + b_2 P_{t-1} + b_3 S_{t-1} + b_4 W_t + V_t$

(Simultaneous Equations Model)

Description	COEFFICIENTS					R^2	F
	b_o	b_1	b_2	b_3	b_4		
Estimate	0.14	0.85	0.17	-0.13	-0.06	0.99	332.05
(S.E.)	0.09	0.06	0.11	0.08	0.07	-	-
SL	0.13	0.00	0.12	0.11	0.36	0.00	0.00

SOURCE: Author's Work.

facilitate the application of the instrumental variable technique in the estimation of the model. Hence the price coefficients at the 11 and 12 percent levels of significance are considered satisfactory for application in further analytical work.

Table 5-21 gives the results of the estimate of the aggregate sugar demand function, based on equation (ii) of the simultaneous equations model (5-11). These results indicate that no significant difference was observed for the two specifications of the aggregate demand function. Hence P_t will be assumed to be endogenous in all subsequent analyses, which is consistent with the theory. The results also indicate that the coefficient for T was not statistically significant at the 10 percent level. Since partial correlation analysis had indicated that N_t, Y_t and T were highly collinear while the Farrar-Glauber tests had suggested that T could be a source of severe multicollinearity, the

TABLE 5-21

Aggregate Sugar Demand Function, Kenya, 1955-1976

Model: $Q_t^d = a_o + a_1P_t + a_2Y_t + a_3N_t + a_4T + U_t$

(Simultaneous Equations Model)

Description	COEFFICIENTS					R^2	F
	a_o	a_1	2_2	a_3	a_4		
Specification 1:*							
Estimate	-0.43	-0.26	0.59	1.59	-0.03	0.99	486.96
(S.E.)	0.38	0.09	0.14	0.75	0.02	-	-
SL	0.28	0.01	0.00	0.05	0.23	0.00	0.00
Specification 2:**							
Estimate	-0.36	-0.23	0.55	1.42	-0.02	0.99	503.64
(S.E.)	0.36	0.07	0.12	0.74	0.02	-	-
SL	0.35	0.01	0.00	0.07	0.35	0.00	0.00

*Specification 1 assumed P_t to be ENDOGENOUS.

**Specification 2 assumed P_t to be EXOGENOUS.

SOURCE: Author's Work.

observed statistical insignificance for the coefficient of variable T even at levels of significance as low as 10 percent can be attributed to the existence of some multicollinearity. This problem could probably be reduced or overcome through the estimation of a per capita demand function. If this were the case, one would expect the estimate of the per capita demand function to give statistically significant structural coefficients at either 10 percent or higher levels of significance.

Table 5-22 gives the IVT estimate of the per capita sugar demand function.

TABLE 5-22

Per Capita Sugar Demand Function, Kenya, 1955-1976

Model: $q_t^d = a_o + a_1P_t + a_2y_t + a_3T + U_t$

(Simultaneous Equations Model)

Description	COEFFICIENTS a_o	a_1	a_2	a_3	R^2	F
Specification 1:						
Estimate	0.56	-0.14	0.45	0.01	0.97	191.39
(S.E.)	0.05	0.07	0.16	0.01	-	-
SL	0.00	0.05	0.01	0.20	0.00	0.00
Specification 2:						
Estimate	0.58	-0.17	0.60		0.96	242.32
(S.E.)	0.05	0.07	0.11	n/i	-	-
SL	0.00	0.02	0.00		0.00	0.00

n/i = Variable Not Included in the Estimating Model.

SOURCE: Author's Work.

The omission of T from the estimating model (given as Specification 2 in Table 5-22) resulted in some minor improvements in the significance levels of the estimated structural coefficients for the included explanatory variables. However, this omission resulted in the loss of one percentage point for the R-squared value of the model estimate. Since the gains from the omission of T are small, one may wish to retain T in the estimating model in order to (i) account for the minor qualitative changes not accountable for in the other variables and thus improve on the value of the R-squared, and (ii) preserve the dynamic structure of the classical demand-estimating model [as proposed in equations (5-6) and (5-7)].

Some Concluding Remarks on the Simultaneous Equations Modelling

For purposes of comparison, the results of the estimates of recursive systems of models given in Tables 5-8, 5-12 and 5-15 are correspondent to the results of the estimates of simultaneous equations models given in Tables 5-20, 5-21 and 5-22 respectively. Estimation of models of supply and demand within a simultaneous equations system is expected to eliminate some bias from the estimates through the application of instrumental variable estimation technique (IVT). This technique appears to give more efficient estimates and also facilitate model estimation in the presence of multicollinearity. This inference is based on (i) the ease with which the estimates of the conventional models of supply and demand analysis were obtained when the IVT method was used, and (ii) the higher significance levels for virtually all the estimators based on IVT estimates when compared with the results based on recursive equation models.

In empirical analysis, one cannot always specify simultaneous equations models and obtain data for the estimation of such models. From the comparison of the results, one can conclude that the estimation of simultaneous equations models is likely to yield more reliable estimates through the elimination of simultaneous equations bias by the application of the IVT estimation method. Therefore, one should apply this approach in empirical studies whenever possible.

Calculation of Elasticities

The results of the estimate of cane and sugar supply functions suggested that the value for the adjustment parameter is close to unity. Hence the values of the calculated short-run and long-run supply elasticities would be very close. This statement explains why no differentiation is made between short-run and long-run supply elasticities in the subsequent discussions.

An examination of what happens to the values of elasticities of supply and demand during the periods of low and high general levels of the economic variables,[1] such as price or income levels, was proposed as a central objective of the analysis of elasticities. A corollary to this objective was the ascertainment of the influence of time on such elasticity values. Answers to the stated objective would be easy to obtain if large samples of time series observations on the relevant economic variables were available. The sample of 22 observations of time series data that was available for this study can be considered as relatively small if the sample were to be used in an analysis to ascertain the influence of time and the general levels of economic variables on the calculated elasticities. However, a method to generate some answers to the stated objectives while making use of the available data was devised for this study.

The proposed approach to the analysis in order to ascertain the influence of time and the general level of the economic variables on elasticity measures was to apply the statistical concepts of means and standard errors in the assessment and evaluation of the analytic results. This technique will be discussed in the ensuing few paragraphs.

Calculations of elasticities from the estimates of general linear regression models are obtained by multiplying the estimates of structural coefficients by the appropriate quotients of the average values of the relevant independent variables and the dependent variables. Hence, if one wishes to calculate the price elasticity (η_p) when $\hat{\beta}$ is the estimate of the coefficient for price and $\bar{P}$, $\bar{Q}$ are the average values for price and quantity variables respectively, then one uses the relationship:

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[1] The terms "general level of a given variable" will be used to refer to the average level of the given variable for a specified time period.

$$\eta_p = \hat{\beta}(\bar{P}/\bar{Q}) \tag{5-12}$$

In this general case, η_p could be the price elasticity of either supply or demand, depending on what is under investigation.

The general method of calculating elasticities from the estimates of regression models, as described by equation (5-12) was adapted and modified to give estimates of elasticities at low, medium and high general levels by incorporating the standard errors in the estimates so that the general estimating relationship is:

$$s\eta_p = \hat{\beta}[\bar{P} \pm SE(p)] / [\bar{Q} \pm SE(q)] \tag{5-13}$$

where $s\eta_p$ is now interpreted as the range for the calculated price elasticity, thus reflecting the confidence interval, and SE(p), SE(q) are the standard errors of $\bar{P}$ and $\bar{Q}$ respectively.

The relationship developed in equation (5-13) can now be used to generate three measures of price elasticity at low, medium and high general price levels as follows:

(i) Elasticity at low general price level:

$$l\eta_p = \hat{\beta}[\bar{P} - SE(p)] / [\bar{Q} + SE(q)] \tag{5-14}$$

(ii) Elasticity at medium general price level:

$$m\eta_p = \hat{\beta}[\bar{P}/\bar{Q}] \tag{5-15}$$

(iii) Elasticity at high general price level:

$$h\eta_p = \hat{\beta}[\bar{P} + SE(p)] / [\bar{Q} - SE(q)] \tag{5-16}$$

The relationships described in equations (5-12) through (5-16) are specified relative to price elasticity measurements. However, the general approach can be applied in the analysis of other measures of elasticities, such as income and cross-price elasticities provided that appropriate interpretations based on theory are made. An assessment of the four equations indicates that equation (5-15) gives the relation that is commonly used in empirical analysis, but there is no theoretical justification for not using the other relations.

The objective of the analysis here was to generate average values of elasticities that reflect the range of elasticities during the transition from low to high general levels of the economic variables. This objective can be accomplished in two steps. First, the three measures of elasticities defined in equations (5-14), (5-15) and (5-16) are calculated. Secondly, a mean for the three measures of elasticity is calculated. This mean elasticity measure is seen to be slightly different from the conventional elasticity measure given by equation (5-15) since the former mean is given by the relationship:

$$\bar{\eta}_p = [l\eta_p + m\eta_p + h\eta_p]\,/3 \qquad (5\text{-}17)$$

where $\bar{\eta}_p$ is the mean elasticity for the three sub-periods as described in the three equations above.

Table 5-23 gives the estimates of the mean elasticities of supply based on the analytic techniques described in equations (5-12) through (5-17) above.

The calculated mean elasticity measures indicate that the production of cane has been more responsive to price changes than the production and supply of sugar has been. These observations could be justified on the grounds that there is more competition from alternative

TABLE 5-23

Mean Elasticities of Supply for Sugar in Kenya
Based on Values at Different General Price Levels

Product	Types of Model*	Calculated Elasticity Own-Price	Calculated Elasticity Cross-Price
I: CANE:	Recursive, Lagged (NAH)	1.00	n/a
II: SUGAR:			
	A: Recursive:		
	(i) Weighted Prices	0.07	-0.05
	(ii) DSAM	0.19	-0.10
	B: SEM:		
	Lagged (NAH)	0.32	-0.18

(1) *The types of models used in the analysis included the lagged type of model that is specified in accordance with the Nerlovian Adjustment Hypothesis (NAH), the weighted prices model, and the dynamic adjustment type of model (DSAM). The models were either determined as recursive systems, or as equations within simultaneous equations models (SEM).

(2) n/a = Not Available, since estimation was not possible, primarily due to the incidence of severe multicollinearity, which generally limited the choice of model specifications.

SOURCE: Author's Work.

enterprises at the cane production level than at the sugar processing and supply levels. The observed large standard errors for the calculated mean elasticities suggest that supply is likely to become more price elastic at high levels of the general price and vice versa. The results also suggest that own-price[1] elasticities could become negative at very low general price levels: this result is conceivable when the general price level of the alternative enterprises is relatively higher than the own-price level. The low level of price elasticity of supply may be an indication of the possibility that costs of sugar production have been rising rapidly as the output level has increased over the last two decades.

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[1] The term "own-price" is often used to refer to the price of the commodity under investigation: the term helps one to distinguish between price elasticity (i.e., own-price elasticity) and cross-price elasticity in a general discussion of elasticities.

The presence of multicollinearity necessitated the use of various specifications in order to get a working estimating model. Since the results of the estimates of a supply function are sensitive to the types of models used, comparisons of the parameter estimates that are associated with different types of model specification are difficult. From the theory and the general assumptions made in the specifications of the models, (i) the lagged prices model (LPM) is basically a stock adjustment model; (ii) the weighted prices model (WPM) is based on a mixture of stock adjustment and adaptive expectations assumptions; and (iii) the dynamic supply adjustment model (DSAM) is primarily an adaptive expectations model with some features of the stock adjustment hypothesis. However, all the models were specified on the basis of the Nerlovian adjustment hypothesis: they yielded statistically significant adjustment parameters at 10 percent or higher levels of significance. The results of the estimates of the various models gave low mean elasticity measures. The average[1] values adopted for further analytical work are:

(a) Average Price Elasticity of Supply of Cane = 1.00

(b) Average Price Elasticity of Supply of Sugar = 0.19

(c) Average Cross-Elasticity of Supply of Sugar (with respect to price index for competitive produce) = -0.11

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[1] This average is based on the mean elasticity measures presented in Table 5-23.

Assuming that the simultaneous equations model estimates give the parameter when the economic agents (producers and consumers) are behaving optimally, a comparison of the calculated elasticities based on recursive and simultaneous equations models suggests that elasticities are relatively higher when the economic agents are behaving optimally. The simultaneous equations model estimate gives a price elasticity of supply that is about 50 percent greater than the calculated price elasticity of supply based on recursive models.

Table 5-24 gives the mean elasticities of demand. The calculations were carried out in accordance with the technique proposed in equations (5-12) through (5-17).

TABLE 5-24

Mean Elasticities of Demand for Sugar in Kenya, Based on Values at Different General Levels of the Economic Variables.

Type of Model*	Calculated Elasticity	
	Own-Price	Income
A: Recursive Models:		
(i) Aggregate, CDM (NTD)	0.20	0.44
(ii) Individual, P-D, CDM (TD)	0.36	0.38
(iii) Individual, SAM (NTD)	0.11	0.32
B: SEM:		
(i) Individual, CDM (TD)	0.19	0.43
(ii) Individual, CDM (NTD)	0.27	0.65
Averages for Further Analytical Work	0.22	0.44

*Both recursive models and simultaneous equations model (SEM) were estimated; CDM refers to the Classic Demand Model while SAM refers to State Adjustment Model. P-D implies that the variables of the model were deflated by the price variable, while the bracket (TD) or (NTD) indicates whether the estimated model is time-dependent (TD) or not time-dependent (NTD), depending on whether the trend variable was included or not included in the estimating model.

SOURCE: Author's Work.

Comparable estimates of the demand function indicate that the inclusion of the trend variable in the estimating model had some effect on the magnitude of the structural coefficients. This comparison was, however, possible only in the case of the simultaneous equations model estimates. In the other cases, the specifications of the models are not comparable. The high value of the estimate of the price elasticity in the case of the price-deflated individual demand model is suspected to be biased upwards owing to the interaction of the price coefficient and the usual intercept term. Taking into account the econometric problems experienced and the differences in model specifications, the estimates of the sugar demand elasticities can be said to be within a comparable range. The low values of the demand elasticities may be a result of lack of close substitutes for sugar and an inherently unstable economy whereby prices of all commodities have been changing relatively faster than changes in disposable income. Given the low demand elasticities, a pricing policy cannot be expected to be very effective in terms of curbing the sugar demand at a high rate.

As in the case of the estimates of price elasticity of supply, the standard error for the calculated price elasticity of demand is relatively high. This result is consistent with the hypothesis that elasticities will be relatively high at high general levels of the commodity prices and vice versa. The inclusion of the time variable in the estimating model appears to moderate this effect, thus giving slightly lower estimates of elasticities for the time dependent models relative to those for the nontime-dependent models of comparable specification. The results also suggest that the elasticities will generally be higher if the economic agents (consumers and producers) are behaving optimally (cf. recursive and SEM estimates).

Implications of the Levels of the Calculated Elasticities

Elasticities give the degree of responsiveness of specified variables to changes in the levels of the factors that influence the given variables. Therefore, the levels of calculated elasticities have some important implications on future developments in the values of the variables they describe. The implied low, medium and high levels of the calculated elasticities that are presented in Tables 5-23 and 5-24 will be used in the projections of production and consumption of sugar in Kenya during the next two decades under alternative assumptions for the growth in the levels of prices and other major factors that influence the levels of supply and demand for agricultural products.

For both supply and demand, the medium level of calculated elasticities leads to the assumption of moderate growth rates. For production, the high level of calculated price elasticity of supply leads to the assumption of high growth rate; conversely, the low level of calculated price elasticity of supply leads to the assumption of low growth rate. For consumption, the low level of calculated price elasticity of demand leads to the assumption of high growth rate; conversely, the high level of calculated price elasticity of demand leads to the assumption of low growth rate. Similarly, the effects of the levels of relevant cross-price elasticities and income elasticities on the relevant growth rate assumptions can be deduced from theory expectations. Projections of production and consumption of sugar in Kenya, based on alternative growth rate assumptions are presented in Tables 5-26 and 5-27.

Estimation of Rates of Growth

Growth rate coefficients are useful when predicting future values for the relevant variables. A number of approaches could be taken when estimating the rates of growth for a given set of variables. The proposal here is to estimate the rates of growth for selected variables that are of interest to the sugar industry using two alternative methods.

The first approach is to use the discounting/compounding technique. Given X_o = the initial value of the variable X, and X_n = the last observed value of variable X, where the period between the observation X_o and X_n is N years, then the annual growth rate coefficient r for X is given by:

$$X_o(1 + r)^N = X_n \qquad (5\text{-}18)$$

The value for r is obtained from equation (5-18) through the usual mathematical computations.

The second approach is to use an econometric method in the determination of the growth rate coefficients. If time series observations on the values of a variable X are available, the basic estimating model for the growth rate coefficient for X can be specified as:

$$X_t = a + bT + e_t, \text{ for } t = 1, \ldots, n \qquad (5\text{-}19)$$

where X_t is the observed value of X at time t, T = 1, ..., n is the time trend variable, e_t is the stochastic variable, and a, b are the underlying structural coefficients of the model. From the theory, b is the time derivative for X, i.e.:

$$b = \frac{dX}{dT} \qquad (5\text{-}20\text{-}1)$$

The growth rate coefficient r for the variable X is obtained from equation (5-20-1) by expressing b in terms of proportionate rates of change, so that the estimating relationship is:

$$r = \frac{1}{X} \cdot \frac{dX}{dT} = \frac{b}{X} \qquad (5\text{-}20\text{-}2)$$

A further relationship that could facilitate in-depth analysis of expected changes in the values of a set of given variables is what will be referred to as growth rate elasticity. This concept can be useful when assessing how the observed growth rates are likely to behave over time. The growth rate elasticity g_e is calculated by multiplying r, the growth rate coefficient, by the average amount of time involved in the observation of X values, so that:

$$g_e = \frac{TdX}{XdT} = b\frac{T}{X} \qquad (5\text{-}21)$$

The econometric approach to determination of growth rate coefficients is considered superior to the discounting/compounding approach on the grounds that the results of the former approach are easily rendered to statistical tests of significance. Further, the econometric approach facilitates estimation of growth rate elasticities and the calculation of the standard errors associated with the growth rate estimates. However, results based on both approaches will be obtained and compared.

Table 5-25 presents for a selected number of variables the estimates of growth rates and associated standard errors and growth elasticities based on the proposed two methods of estimation.

TABLE 5-25

Estimates of Growth Rates and Associated Standard Errors and Growth Elasticities for Selected Variables in Kenya, 1955-1976

Selected Variable	**Estimated Percentage Annual Growth Rate		Associated	
	E/M Method	D/C Method	Growth Elasticity	Standard Error
1. Cane Production	10.2	9.9	0.81	10
2. Cane Producer Price	6.3	7.2	0.51	23
3. Sugar Production	11.0	11.6	1.27	10
4. Sugar Consumption:				
(i) Total	6.7	7.1	0.77	6
(ii) Per Capita	3.2	3.4	0.37	7
5. Retail Sugar Price	5.0	5.7	0.58	22
6. Maize Producer Price	1.6	2.8	0.18	56
7. Consumer Price Index:				
(i) Composite	2.9	3.5	0.33	14
(ii) Foods only	2.8	3.3	0.33	15
8. Population	3.6	3.6	0.42	2
9. Disposable Income:				
(i) Total	9.5	9.7	1.09	11
(ii) Per Capita	6.1	5.9	0.70	11
10. World Sugar Price***	9.2	5.9	1.06	33

**The two alternative methods of estimation used are:
(i) D/C for the Discounting/Compounding Method;
(ii) E/M for the Econometric Method.

***The estimates related to the world market for sugar are introduced to facilitate comparison.

SOURCE: Author's Work.

The results presented in Table 5-25 show that the discounting/compounding technique and econometric method for estimating growth rates will yield relatively comparable estimates. The estimates will be closer if the variable concerned has not fluctuated much during the observation period (see the associated standard errors and the estimated growth rates).

The following are the main observations that are made from the results of Table 5-25:

1. Cane production has grown at a slightly lower rate than that for sugar production during the sample period. Since cane is the raw material for sugar production, one would expect the growth rates for cane and sugar production to be comparable. Any minor differences in the two rates of growth could be attributed to technological improvements that may lead to recovery of higher amounts of sugar from a given quantity of cane;

2. Both cane and sugar production exhibit relatively higher growth rates than those for the corresponding cane and sugar prices. This result suggests that changes in cane and sugar prices have had an impact in raising the levels of cane and sugar production;

3. Total sugar consumption has experienced a high rate of growth relative to growth in the retail price of sugar. The consumption level appears to have kept pace with growths in population and income, as the relevant growth rate coefficients suggest;

4. Sugar production exhibits a higher rate of growth than that for consumption so that the failure of the sugar industry to achieve the policy goal of a self-sufficiency status 15 years after the initiation of the policy can be attributed to the initial low and high production and consumption levels respectively;

5. Relative to the overall rate of inflation in Kenya, cane and sugar prices can be said to have grown fairly rapidly during the sample period.

An examination of the associated growth rate elasticities and standard errors which are presented in Table 5-25 indicates that prices have fluctuated more than any other variables during the sample period. The results also suggest that the world market sugar price has had the highest degree of fluctuation. Maize price was hypothesized to have some influence on the cane production levels. This price is seen to have fluctuated more than the price of cane during the same period, but the price of cane is seen to have grown faster relative to the maize price. Given these interactions, the actual effect of the changes in the cane and maize prices may be said to depend on the initial levels of these prices.

A final comment on the methods of estimating growth rates is worth making: the estimates can be expected to be sensitive to the method used. If the difference between the initial and final value of the variable under investigation is low while the variable is known to have fluctuated wildly during the intervening period, then the discounting/compounding method would give biased estimates. The same result would hold if the difference between initial and final observations is very high while the variable is known to have remained relatively stable during the intervening period. From this point of view, the econometric method would give more reliable estimates.

The assumption that the coefficient of the time trend factor is the only determinant of the growth rate coefficient is an oversimplification. A more realistic approach would be to incorporate the influence of other variables that influence the levels of the variable under investigation in the growth-rate estimating model. This proposition will be applied in the section on projections of quantities supplied and demanded during the next decade [see equations (5-22) and (5-23)].

Projection of Domestic Production and Consumption of Sugar in Kenya

Projections give estimates of future values for a given set of variables and can thus be useful as guidelines for future planning. The purpose of the analysis here is primarily to generate information that can be used in the assessment of the self-sufficiency policy for sugar production in Kenya.

Most studies concerned with projections or forecasting assume constancy in structural variables of the model and in the policy or political environment.[1] The assumption of constant policy may be feasible for domestic-related projections. However, the assumption of constant structural variables for analytical models need some modifications in order to improve the reliability of the estimates that are based on such models, especially if long periods of projections are involved. In this analysis, direct incorporation of the time influence in the prediction models is proposed as a means to allow structural growth in the variables that influence the dependent variables.

The proposed method of projections in this study is a combination of econometric methods and mathematical analysis. The dependent variable is assumed to grow exponentially so that the elasticities of the independent variables with respect to the dependent variable and the growth rate coefficients of these variables are incorporated in the projections model. The result is a dynamic model whose general structure can be specified in two steps: if Q is the variable whose values are to be projected and $X_1, X_2, \ldots, X_n$ are the independent variables that influence the values for Q, then:

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[1] See, for example, J.J. Richter, "International Trade Models and Product Studies as a Base for Worldwide Decision-Making in Agriculture," In Decision-Making and Agriculture (IAAE Conference Proceedings, 1976); and FAO, Agricultural Commodities: Projections for 1975 and 1985, Vol. I and II (FAO, Rome, 1967).

(i) annual changes in the value of Q are given by:

$$\frac{dQ}{QdT} = e_1 \frac{dX_1}{X_1dT} + e_2 \frac{dX_2}{X_2dT} + \ldots + e_n \frac{dX_n}{X_ndT} \qquad (5\text{-}22)$$

(ii) level of Q by the end of a given year is:

$$Q_{t+1} = Q_t(1 + \frac{dQ}{QdT}) \qquad (5\text{-}23)$$

where Q_t and Q_{t+1} are the respective values of Q at the start and end of the given year, and $e_1, e_2, \ldots, e_n$ are the respective elasticities of $X_1, X_2, \ldots, X_n$ with respect to Q. Further, an expression such as dQ/QdT or dX_i/X_idT is the growth rate coefficient for Q or X_i: such a coefficient is called the rate of inflation if the variable were the general price level in the economy. The general predictions method defined by equations (5-22) and (5-23) is similar to the method that has been used by FAO in the projection of demand for agricultural products.[1]

For the general specification of the model, Q could be any variable that is of interest to the analyst. There are two possible approaches to the determination of future values of Q using the method proposed in equations (5-22) and (5-23). The first approach is to determine the value of dQ/QdT by econometric methods. In this case, the proportionate annual changes in Q are regressed on the proportionate annual changes in X_i (for i = 1, 2, ..., n) in order to generate an estimate for dQ/QdT that can then be applied in equation (5-23). This approach generates e_1, e_2, ..., e_n as the estimates of the structural coefficients of the econometric model specified by equation (5-22). The second approach is to use the compounding technique so that dQ/QdT is approximated by the value of the compounding factor.

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[1] See, for instance, FAO, "Agricultural Commodity Projections for 1970," in Commodity Review: Special Supplement (FAO, Rome, 1962); and FAO, Agricultural Commodity Projections, 1970-1980, Vol. I and II (FAO, Rome, 1971).

The first approach is preferred for this study since it incorporates changes in the values of independent variables in the projections model and the results can be subjected to statistical tests of significance. Table 5-26 gives the results of the projection of domestic production and consumption of sugar in Kenya.

Taking into account the premise under which projections of agricultural products are made, the projections for consumption are more likely to be realized. The same statement could not be made for the projections of production with the same degree of confidence. Increased production can be expected primarily through bringing of new land into cultivation, yet this option is not always feasible. Hence the sustenance of past growth rates is more difficult in the case of production, and the actual production levels in the future may fall short of the projected levels. Consequently, the projected percentage self-sufficiency levels are likely to overstate the true situation.[1]

The projections of domestic production and consumption of sugar in Kenya indicate that the country could become self-sufficient in sugar by the end of 1987 if the previous average levels of the general economic conditions can be sustained. The growth rate coefficients used in the projections were obtained through the application of the techniques

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[1] The self-sufficiency level was assessed by an index of the ratio of total domestic production to total domestic consumption (see Table 5-26).

TABLE 5-26

Projections of Domestic Production and Consumption of Sugar in Kenya, 1976-1990; 2000

[Thousand Metric Tons]

Year	Production (growth rate = 0.1032)	Consumption (growth rate = 0.0769)	Percentage Self-Sufficiency Index
1976	190	248	76.6
1977	210	267	78.7
1978	231	288	80.2
1979	255	310	82.3
1980	281	334	84.1
1981	310	359	86.4
1982	343	387	88.6
1983	378	417	90.6
1984	417	449	92.9
1985	460	483	95.2
1986	507	520	97.5
1987	560	560	100.0
1988	617	603	102.3
1989	681	650	104.8
1990	751	700	107.3
*	*	*	*
2000	2007	1468	136.7
*	*	*	*

*Projections for year 2000 are added to assess the situation one decade after 1990. All quantities are rounded off to the nearest thousand metric tons.

SOURCE: Author's Work.

proposed in equations (5-22) and (5-23), and are found to be slightly different from those obtained through simple disounting/compounding and trend-based econometric methods (cf: results in Table 5-25).

On *a priori* grounds, one could argue that future sugar production cannot be expected to grow at a rate higher than or comparable to that experienced in the last decade. The relatively fast growth rate in production in the past can be attributed primarily to opening of new areas for cane production and establishment of sugar mills in such new areas, although some improvements in technology could account for part of the growth. Given the increasing land pressure in the cane-producing zones, primarily due to population growth, and taking into account the limitations of arable land that could be brought into cane cultivation, one may conclude that the level of growth in sugar production that was experienced in the 1970s is unlikely to be sustained during the 1980s. Hence the recommendation that Kenya will be self-sufficient in sugar by 1981, if the proposals to rehabilitate and expand existing sugar schemes are implemented by 1980, would appear to be over-optimistic.[1] However, conditions for increased production at higher economic and social costs may exist.[2]

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[1] The recommendations are based on feasibility studies done by Government Consultants and are *quoted* in Ministry of Agriculture, "Projections on White Sugar Consumption in Kenya to 1990: Their Reconciliations with Sugar Production and Policy Implications" (unpublished Paper, Ministry of Agriculture, Nairobi, Kenya, 1977).

[2] Projections require frequent updating, depending on current information. The opening of the sugar schemes at Nzoia (Western Province) and Awendo (South Nyanza Province) may drastically affect the outlook.

Parametric Analysis of Production and Consumption of Sugar

An argument that projections are more likely to be realized in the case of consumption rather than production has been advanced in a previous paragraph. The analysis based on the assumption of moderate growth rates indicates that Kenya could attain self-sufficiency in sugar by the end of 1987; this result contradicts a recommendation based on some feasibility studies. A more realistic approach to the projections would be to establish the lower and upper limits for the projected variables, and this is the essence of parametization in this section.

Parametric analysis can facilitate the establishment of the shortest and the longest times possible for the achievement of a stated objective. The analysis involves the application of the standard errors of the means for the relevant variables under study. The shortest time possible during which Kenya could achieve the self-sufficiency status in sugar can be obtained by carrying out projections under the assumptions of high growth rate in production and low growth rate in consumption. Conversely, the longest possible time during which self-sufficiency could be achieved would be obtained by carrying out the projections under the assumptions of low growth rate in production and high growth rate in consumption. All projections are based on the assumption that past and prevailing economic conditions would persist in the future. Hence the standard errors of the means can be added or subtracted from the relevant means to give high or low values of the relevant variables.

The average growth rate for sugar production was calculated to be 10.32 percent per annum, this value being associated with a standard error of the magnitude of about 10 percent. The growth rate for sugar consumption was similarly calculated to be 7.69 percent per annum, the value being associated with a standard error of the magnitude of about 7 percent. Based on these values, the high and low growth rates for sugar production would be 11.35 and 9.29 percent per annum respectively. Similarly, the high and low growth rates for sugar consumption would be 8.23 and 7.15 percent per annum respectively.

Under the assumptions of high growth for production and slow growth for consumption, Kenya could become self-sufficient in sugar by the end of 7 years effective 1976. Under the assumption of slow growth for production and high growth for consumption, the country would become self-sufficient in sugar by the end of 27 years effective 1976. As already observed in Table 5-26, the country is expected to become self-sufficient in sugar by the end of 11 years, effective 1976, under the assumption of moderate growth rates. Table 5-27 gives a summary of expected dates for Kenya to become self-sufficient in sugar under alternative growth rate assumptions.

TABLE 5-27

Expected Dates for Kenya to Become Self-Sufficient in Sugar Under Alternative Growth Rate Assumptions

[Projections Base Year = 1976]

Assumptions	Expected Dates for Attaining Self-Sufficiency Status (Year)
1. Slow Growth in Production and Fast Growth in Consumption	2003
2. Moderate (Average) Growths in Both Production and Consumption	1987
3. Fast Growth in Production and Slow Growth in Consumption	1983

SOURCE: Author's Work.

On empirical grounds, higher growth rates in production and slower growth rates in consumption than the ones embraced in the three assumptions of Table 5-27 are unlikely to be achieved: the calculated price elasticities of supply and demand and the income elasticity of demand were shown to be low, which suggests that a pricing policy cannot significantly alter the general trend. Hence the Government feasibility studies that predict the attainment of a self-sufficiency status for sugar before 1983 would still appear to be over-optimistic, as the results based on Assumption 3 in Table 5-27 would indicate.

Following the conventional use of arithmetic means in the assessment of results, 1987 can be taken as the most likely early date for the attainment of self-sufficiency in sugar production in Kenya. The projected results show that Kenya could have 2.3 percent of its domestically produced sugar available for export, or storage as stocks, by the end of 1988. This percentage of exportable surplus of sugar would rise to 4.8 by 1989 and to 7.3 by 1990. A long-term forecast would indicate that the percentage of exportable sugar surplus would be 36.7 by the year 2000 (see Table 5-26).

Hypothesis Testing and Other Evaluations

This section examines the major hypotheses that were to be tested and presents some further evaluations of the analytic results. The major hypotheses to be tested were formulated relative to the sugar industry in Kenya. Further evaluations relate to the performance of the sugar industry.

The following hypotheses are accepted on the grounds that the relevant structural coefficients were found to be statistically significant at 10 percent or higher levels of significance:

(i) Domestic production of cane and the supply of sugar are influenced by the general cane and sugar price levels;

(ii) Domestic production of cane and sugar is adversely affected by the general price level for competitive enterprises, the major variable here being the price of maize;

(iii) Domestic demand for sugar is determined by the general level of sugar price and the national disposable income;

(iv) Domestic price for sugar is correlated to the world market price for sugar;

(v) The degree of adjustment of domestic cane and sugar production following changes in the cane and sugar prices has been statistically significant.

The other major hypotheses to be tested had to do with the testing of the effectiveness of the Government sugar policy and the determination of the time when the country could be expected to achieve the self-sufficiency status in sugar. There may be no one easy way of testing whether a given program has been effective, unless it has achieved its objectives fully. The objective of the Government sugar policy has been to achieve self-sufficiency in sugar at the earliest possible period: pricing has been used as the major instrument towards this end. A proposal for testing the effectiveness of this policy is to calculate a coefficient for the degree of effectiveness and compare this coefficient with other relevant structural variables.

The approach to the evaluation of the policy effectiveness that is proposed here involves an examination of the performance of the sugar industry relative to the policy goal of self-sufficiency since 1966, the time when the Government began to regulate the industry. The domestic production and consumption levels by then were 36 and 121 thousand metric tons of sugar respectively so that the sugar imports level stood at 85 thousand metric tons at that time. An effective self-sufficiency program could be defined as one that could have brought down the imports figure from 85 thousand metric tons to zero at the earliest time possible, or within the target period. Given that the Government had hoped to achieve self-sufficiency in sugar by the early 1970s, the production and consumption situation in 1976 will be used as the benchmark in the analysis.

The production and consumption levels in 1976 stood at 190 and 248 thousand metric tons respectively, 10 years after the initiation of the Government policy. The imports level at this time thus stood at 58 thousand metric tons. An effective program should have reduced the imports level to or close to zero by this time. Hence the effectiveness of the Government policy between 1966 and 1976 can be calculated as:

$$\left[\left(\frac{85 - 58}{85}\right) \times 100\right] = 31.76 \qquad (5\text{-}24)$$

in percentage points. This gives an effectiveness coefficient of about 3.18 percent per annum during the target period. A further proposal is the notion that an effective program should have reduced the imports gap by an annual rate that is close to the rate of growth in consumption so that production must have been growing at a much higher rate.

The calculated coefficient of policy effectiveness at 3.18 percent per annum is seen to be low relative to the consumption growth rate coefficient at 9.40 percent per annum. Hence the hypothesis that the Government sugar policy is effective is modified and accepted in the format that the policy has not been relatively effective in curbing demand and fostering production in order to achieve its objectives within the target period.

The hypothesis about the period when Kenya could become self-sufficient in sugar is closely linked to the effectiveness of the Government policy. The projections and the parametric analysis suggest that the hypothesis should be modified and accepted in the format that the country could be expected to achieve self-sufficiency in sugar by the end of the 1980s at the prevailing general level of economic conditions. However, some measures must be taken to sustain or raise the average growth rate in sugar production while ensuring that the growth rate in sugar consumption does not exceed the prevailing average level (see Tables 5-26 and 5-27).

The second objective of evaluations was to derive a general measure of market performance and use it in the assessment of the performance of the sugar industry. Market performance can be defined as an industry's contribution relative to its potential to the achievement of (i) efficiency in the use of resources, (ii) progressiveness in enlarging and improving the flow of goods and services, (iii) stability of prices and employment, and (iv) fairness in the treatment of individuals.[1] However, more norms could be added to the list of performance criteria so that a general approach to the assessment of market performance could involve the evaluation of the degree of achievement of prespecified goals. The proposal here was to assess the general performance of the sugar industry relative to the prescribed policy goal of self-sufficiency.

The calculated coefficient of policy effectiveness (see equation 5-24) can be taken as one measure of the performance of the industry relative to the policy goal, the ideal being unity. Using this criterion, the coefficient for market performance during the target period of 10 years (1966-1976) is 0.32, which is relatively low. Another related measure of market performance would be an index of the annual movements in the ratio of total domestic production to total consumption. Such a measure was described as percentage self-sufficiency index (Table 5-26), the ideal being 100 percent. Calculations of this index show that its value has risen from a level of 29.8 percent in 1966 to 76.6 percent in 1976, the actual change being an indication of the improvements in the self-sufficiency status during the target period. This improvement in the self-sufficiency status generates a coefficient for market performance of the order 0.47 during the ten-year period.

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[1] R. Caves, American Industry: Structure, Conduct, Performance (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1977), pp. 66-83.

The measure of improvements in the self-sufficiency status appears to be high relative to the coefficient of policy effectiveness, but the two measures are related since they assess market performance relative to a policy goal. A major weakness of the two indices of performance is that they do not tell how the market performs from year to year during the target period: they are aggregative and average in nature. However, the self-sufficiency index, when given on a yearly basis for the entire period, could overcome the aggregation problem. Like most other measures of market performance, the policy effectiveness and self-sufficiency improvement coefficients have to be judged relative to some predetermined levels of satisfactory performance. Although the definition of such levels may introduce some subjectivity in the analysis, such a step is needed in order to arrive at operational criteria. For this evaluation, performance indices of the order of 0.75 or above could be taken as acceptable levels of satisfactory performance, when the ideal level is unity.

Given the low policy effectiveness coefficient (0.32) and the self-sufficiency improvement coefficient (0.47), the performance of the sugar industry in Kenya can be said to have been unsatisfactory relative to the achievement of the prescribed self-sufficiency status. The application of other performance norms was limited by the lack of more information on the sugar industry. However, there is evidence that the performance of the industry has been satisfactory if the price, employment and output stability criterion is used. The Kenyan sugar price has been stable relative to the world sugar price (see Figure 5-5), and employment and output in the sugar industry is said to have grown steadily since 1964. Further, labour relations in the industry have been satisfactory.[1]

Summary and Overall Evaluation

This chapter has presented a discussion of the data and data treatments, analysis and the analytic results, and some applications and evaluations of the analytic results. Some emphasis was laid on how the analytic results were used in the assessment and evaluation of the market structure, especially in relation to (i) the general market behaviour in terms of market practices and price movements, and (ii) the performance of the sugar industry in Kenya in relation to the self-sufficiency policy.

The analysis indicates that the results are sensitive to model specification and estimation methods. Hence proper model specification and estimation methods are crucial in empirical analysis. The time trend factor and the [0,1] dummy variable were found to be highly collinear. Owing to the inclusion of a trend variable, or the incorporation of time factor in the analytic models, the use of a [0,1] dummy variable for the periods before and after the initiation of the self-sufficiency policy in 1966 was found to be statistically insignificant at the 10 percent level. The Chow test for structural change was found to be negative for all estimating models too. Hence the changes in policy after 1963 do not appear to have significantly changed the structural parameters of the sugar market in Kenya.

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[1] E.T. Gibbons, "The Characteristics, Structure and Development of Kenya's Food, Feedstuffs and Beverage Industries," Quarterly Journal of International Agriculture, Vol. 15, No. 2 (April/June 1976, DLG Verlag Frankfurt), pp. 141-160.

Unlike the findings of previous studies on the sugar industry in Kenya, the results of this analysis indicate that both sugar production and consumption are sensitive to economic incentives. However, the relatively low price and income elasticities (see Tables 5-23 and 5-24) suggest that the use of a pricing policy to influence sugar production and consumption in order to achieve the self-sufficiency status will require a move toward a relatively high consumer price for sugar. Alternatively, a pricing policy alone may take a relatively long time to achieve its objectives and questions can be raised about social desirability of such a policy. This factor is considered crucial in the formulation of an alternative sugar policy.

With regard to the parameters related to the main structural variables of the sugar market, the results obtained for Kenya are comparable with those obtained elsewhere in the world.[1] In all instances, production and consumption of sugar have been found to be responsive to price so that a pricing policy would have some impact on the levels of sugar production and consumption. Table 5-28 gives the comparisons of the relevant parameters obtained for Kenya and those obtained at the global level.

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[1] See the review of the world sugar economy in Chapter II, especially the section on specific literature review.

TABLE 5-28

Comparisons of Relevant Growth Rates and Elasticities for the Sugar Industry: Kenya and World Estimates (Data Base: Between 1950 and 1976)

Description	Kenya	World (Range)
I: Annual Percent Growth Rates:		
(i) Sugar Production	11.3	3.3 - 5.6
(ii) Sugar Consumption	6.9	3.6 - 5.8
II: Elasticities:		
(i) Supply of Cane [Price]	1.0	0.3 - 1.0
(ii) Demand for Sugar:		
(a) Price	0.2	0 - 1.5
(b) Income	0.4	0 - 2.0
III: *Coefficient of Determination (R^2) for Prices-Income Consumption Model:	0.90-0.98	0.60-0.85

*Sensitive to model specification. This remark is generally valid for all results.

SOURCE: Author's work and Synthesis from various studies that are cited in Chapter II.

As the results in Table 5-28 indicate, the rate of growth in production and consumption of sugar in Kenya has been relatively fast, a factor that may reflect the efforts that have been allocated to the development of the sugar industry in Kenya since 1966. The results of this study show that prices and income do explain a higher variation in the observed consumption levels in Kenya than that obtained elsewhere in the world. Finally, the relevant elasticities obtained for Kenya are within the range obtained for the other sugar industries in the world.

Hence one can conclude that the results of this study are consistent with what has been found about the structural variables of the sugar markets in the rest of the world, particularly with respect to cane-based sugar industries.

CHAPTER VI

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary and Conclusions

Objectives

The following were the main objectives of the study, each objective being stated in relation to the sugar industry in Kenya:

(i) The determination of the nature of demand and supply functions for sugar and the assessment of the structure and the general behaviour of the sugar industry;

(ii) The assessment and evaluation of the performance of the sugar industry in relation to the policy goal of self-sufficiency;

(iii) The assessment of future trends in production and consumption in order to predict future developments in relation to the policy goal of self-sufficiency;

(iv) The formulation of some market improvement proposals that could find useful application in the sugar industry. Basically, such proposals would derive from the implications of the study and can thus be viewed as defining a set of policy recommendations which could be an aid to those involved in development and improvement planning for the industry.

Hypotheses

The following are the main hypotheses that were tested, each hypothesis being stated in relation to the sugar industry in Kenya:

(i) Cane production and sugar supply are responsive to changes in cane and sugar prices;

(ii) Sugar production is adversely affected by maize production, the main alternative enterprise in the cane-production zones of Kenya;

(iii) There is a lag in adjusting the level of cane and sugar supply to the desired levels following a change in the cane and sugar prices;

(iv) The demand for sugar is responsive to changes in sugar price;

(v) The demand for sugar is responsive to changes in disposable income;

(vi) The domestic sugar price is correlated to the world market price for sugar;

(vii) The Government sugar policy has been effective;

(viii) The sugar industry in Kenya can be expected to achieve the self-sufficiency status by the end of the 1980s.

A Discussion of Models, Methods of Analysis and Results

In order to seek some answers to the questions that derive from the stated objectives of the study and be able to test the given hypotheses, (a) the basic data were subjected to such analytic procedures as (i) correlations analysis, (ii) price trends analysis, (iii) price spreads analysis, and (iv) assessment and comparison of relative changes in the general levels of the various variables, and (b) models for (i) estimating supply and demand functions, (ii) determining the rates of growth and the relevant growth elasticities, and (iii) projecting domestic production and consumption of sugar were formulated, estimated and applied. The basic estimation techniques involved the methods of least squares.

The estimating models were subjected to scanning techniques and tests for such econometric problems as autocorrelation, heteroscedasticity and multicollinearity in order to determine the appropriate estimation methods. The estimates of such models were also subjected to tests of statistical significance in order to determine the results that could be used in further analysis and evaluations. Such tests and scanning procedures indicated that (i) heteroscedasticity was not a serious problem; (ii) autocorrelation was present in some isolated cases; and (iii) multicollinearity was present and severe in most cases where multiple regression models were being estimated. Consequently, appropriate remedial measures and estimation methods in the presence of these econometric problems were executed before obtaining the estimates of the models.

The remedial measures taken for autocorrelation in the cases where the problem was found to exist involved the use of the Cochrane-Orcutt iterative technique. Two methods of estimation in the presence of multicollinearity were proposed and used in this study. The first method involved the use of weighted prices models, while the second method involved the use of models in which some variables are deflated with specified indices.

The weighted prices models and the models in which some variables are deflated with specified indices were referred to as WPM and DSAM respectively in the main text of the thesis. Both types of models were found to be facile as supply-estimating models in the presence of multicollinearity. The estimation of per capita (individual) rather than the aggregate demand functions as specified in equations (5-6) and (5-7) was also found to facilitate estimation in the presence of multicollinearity.

The results obtained from (i) the estimation of supply and demand functions, (ii) the estimates of growth rates for relevant variables, and (iii) the calculations of relevant elasticities were used in the application of these projections models. This step of the analysis was intended to give some results that could be used in the assessment and evaluation of the policy goal of self-sufficiency. A general observation from the analysis was the fact that the empirical results, both in absolute magnitudes and in the levels of statistical significance, were sensitive to model specification and the estimation methods that were used.

The following is a summary and discussion of the main results of the analysis:

(a) Results of Hypothesis Testing

The following hypotheses, which are stated in relation to Kenya's sugar industry, were accepted on the grounds that the estimates of the relevant structural coefficients were significant at the 10 percent or higher levels of significance:

(i) Domestic production of cane and supply of sugar are influenced by the general level of cane and sugar prices;

(ii) Domestic production and supply of sugar are adversely affected by increases in the level of prices for competitive products, the major factor in this case being the level of maize prices;

(iii) Domestic demand for sugar is determined by the general levels of sugar price and the national disposable income;

(iv) Domestic price of sugar is correlated to the world market price for sugar;

(v) The lag in the adjustment of cane and sugar production to desired levels following changes in cane and sugar prices is statistically significant.

Two other hypotheses were to be tested: these hypotheses related to the effectiveness of the Government sugar policy and the time when Kenya is likely to become self-sufficient in sugar:

(i) From the self-sufficiency norm, and given the ten-year period between 1966 and 1976 as the policy target period, the hypothesis that the Government sugar policy has been effective was rejected;

(ii) Based on results of projections and parametric analysis of domestic production and consumption of sugar, the hypothesis that Kenya is likely to become self-sufficient in sugar during the 1980s was accepted.

(b) Discussion of Market Structure Analysis

The estimates of supply and demand functions gave results that were consistent with economic theory. Cane and sugar prices were found to be statistically significant as the determinants of the domestic production and supply of sugar. The general price level for the competitive produce was found to adversely affect the levels of cane and sugar production. The levels of sugar price and disposable income were found to influence the pattern of sugar consumption.

Calculations of elasticities showed that both supply and demand elasticities are low, but are associated with relatively large standard errors. The results indicated that both supply and demand are likely to become relatively more price elastic at a high level of the general commodity prices and relatively more price inelastic at a low level of the general commodity prices. The inclusion of a trend factor in the estimating models moderated the difference between elasticity estimates for periods of low and high levels of general commodity prices.

The rate of growth in domestic production of sugar was found to be close to the rate of growth in domestic production of cane. Both cane and sugar production were found to have grown relatively faster than the general level of cane and sugar prices during the same period. Sugar consumption was also found to have had a relatively higher growth rate than that for the retail price of sugar. The growth in consumption was found to be closely linked to the growth in population and disposable income.

Although the rate of growth in consumption was found to be high relative to the rate of growth in the retail price of sugar, the latter rate of growth can be said to have been high when compared with the overall rate of inflation during the sample period (see Table 5-25).

A comparison of the rates of growth and the associated growth elasticities for various variables indicated that prices had fluctuated more than any other variable during the sample period (see Table 5-25). The results indicated that maize price had grown relatively more slowly than the cane and sugar prices, although the former price had higher annual fluctuations than the latter price. Since maize price was also found to have had a statistically significant negative impact on the levels of cane and sugar supply, despite its low growth rate and high degree of fluctuation, this price is likely to have been at a more competitive initial level relative to the level of cane and sugar prices. The world market price for sugar was found to have been relatively more unstable than the Kenyan sugar price during the sample period.

Production was shown to have grown slightly faster than consumption during the sample period. The failure of the industry to attain the self-sufficiency status during the policy target period (1966-1976) is thus attributable to the low initial level of production and a relatively higher initial level of consumption. The high rate of growth in production relative to the slow rate of growth in cane and sugar prices is attributable to the relatively high price elasticity of supply for cane. The high rate of growth in consumption of sugar can be attributed to the low price elasticity of demand and the relatively higher income elasticity of demand for sugar.

(c) A Discussion of General Market Behaviour and Performance

Sugar is quoted to have become cheaper relative to other foods at the global level.[1] This quotation does not apply to Kenya: the index of the retail price of sugar in Kenya was at the same general level as the consumer price index (CPI) for all foods in 1955, this level being slightly higher than that for the composite CPI in 1970 prices. Since 1955, sugar has become more expensive than other foods in Kenya (see Appendix A-3). The Government policy on pricing of sugar has been one in which the domestic price is maintained at a level that is slightly higher than the level for the average world market price for sugar.[2]

The analysis of domestic sugar price trends indicated that producer, wholesale and retail prices had remained relatively stable until these prices experienced sharp increases after 1972. The general trend in domestic prices was found to be linked to the movements in the world market price for sugar, although the domestic price has generally been sticky in a downward direction. The analysis of trends in price spreads showed that both wholesale and retail price spreads followed the same general trend as that for the producer, wholesale and retail prices up to 1972. After 1972, the wholesale price spread continued to follow the general trend in price increases, while the retail price spread started to have a downward trend (see Figures 5-1 through 5-5).

The performance of the sugar industry was found to have been unsatisfactory when judged in relation to the policy goal of self-sufficiency, but satisfactory when gauged from the price and employment stability and labour relations criteria. The observation that something may be judged to be satisfactory when examined from one perspective but unsatisfactory when judged from another perspective, is a common facet of reality that has led to considerable market research work in the past.[1] Such market research work in the past has been designed in order to establish operational norms or criteria for the evaluation of market performance, particularly with regard to the competitiveness of the marketing system. What can generally be agreed about this problem in empirical analysis is the fact that one has to specify a set of economic objectives for a system and then use that set of objectives as the benchmarks in the evaluation of the performance of the given system.

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[1] See Chapter II of the thesis.

[2] The current (1978) domestic price of sugar at Kshs 4.50 per kg is about 20 percent higher than the average world market price (based on the 1977 ISA floor and ceiling prices of US $245 and $470 per metric ton of raw sugar respectively, and an appropriate conversion factor).

Projections and parametric analyses indicated that Kenya is likely to become self-sufficient in sugar by the end of 1987 if the past moderate pace of developments in production could be maintained. Under an assumption of fast growth in production and slow growth in consumption, the date for achieving self-sufficiency in sugar could be as early as the end of 1983. However, this date could be as late as the end of the year 2003 if the assumption of slow growth in production and fast growth in consumption is adopted (see Table 5-27). The moderate growth assumption that leads to the prediction of 1987 as the date for achieving self-sufficiency in sugar is considered more feasible than the assumption under which the year 1983 is predicted as the date for achieving the self-sufficiency status. Given the economic conditions and the results of the analysis, one may state with some degree of confidence that the date for achieving the policy goal of self-sufficiency could lie anywhere between the years 1983 and 2003.

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[1] The original and leading contributions in this area include: (i) J.M. Clark, "Toward a Concept of Workable Competition." American Economic Review (June 1940); (ii) S.H. Sosnick, "A Critique of the Concepts of Workable Competition." Quarterly Journal of Economics (August, 1958); (iii) J. Markham, "An Alternative Approach to the Concept of Workable Competition." American Economic Review (June 1950); and (iv) S.H. Sosnick, "Toward a Concrete Concept of Effective Competition." American Journal of Agricultural Economics (November, 1968).

Concluding Remarks on Market Analysis

The real price for sugar and the real disposable income were found to have remained relatively low and stable for most of the sample period, the only change in this general trend having been recorded after 1972 (see Appendices A-1 and A-4). This trend in the real prices and income may have led to the observed relatively low supply and demand elasticities. However, low price and income elasticities of demand may also be a result of a fast-growing demand for sugar, while the low price elasticity of supply may be a result of fast-rising cost of sugar production.

The Government has been involved in the regulation of the sugar industry in Kenya since 1966. This Government involvement in the sugar industry does not appear to have affected the rate of market adjustment following changes in the general levels of the economic variables, especially with regard to price changes. This conclusion is based on the observation that there were no significant differences between the estimates of the demand functions which were obtained from alternative estimating models whose specifications are based on alternative assumptions of endogeneity and exogeneity for the price variables. Thus the role of the Government in pricing can be likened to the role of an auctioneer in price formation.

Implications of the Analytic Results

Previous studies on the sugar industry in Kenya, particularly with regard to sugar consumption, have concluded that price and income coefficients are not statistically significant. However, the multiple coefficients of determination (R-squared values) for the estimated regression models in such studies have been of the order of 0.9, or even higher in some cases. Examples of such studies include Frank (1964), Clark (1968) and Ministry of Agriculture (1977).[1] These previous studies have also concluded that the time trend factor has been the major determinant of trends in sugar consumption.

One could question the economic validity or justification for such conclusions as the ones made in the previous studies on sugar in Kenya, but these conclusions are not a surprise, especially if one considers that the partial correlation coefficients for the main independent variables in the estimating models have been found to be relatively high. Theory suggests that such results as the ones quoted in the previous studies may be an outcome of model estimation in the presence of multicollinearity when appropriate remedial measures for the problem of multicollinearity are not taken.[2] Since this econometric problem is likely to occur at severe levels in multiple regression analysis, conclusive tests for the absence of this problem are necessary before one can assess the reliability of empirical estimates of multiple regression models. The results of the previous studies on sugar in Kenya are considered to be of doubtful reliability because the problem of multicollinearity does not appear to have been examined during such studies.

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[1] See the review of literature on Kenya's sugar industry (Chapter III).

[2] See D. Orr, op. cit., pp. 54-62.

This study disproves the validity of the conclusions of the previous studies on the sugar industry in Kenya and demonstrates the importance of proper specification of the analytic models and the use of appropriate estimation methods. The results indicate that both production and consumption of sugar in Kenya are sensitive to changes in the levels of economic variables, especially with respect to changes in prices and disposable income. Given these results, one can expect a pricing policy to be effective in regulating production and consumption. However, the impact of such a policy is likely to manifest itself at a slow rate because the values for the calculated price and income elasticities were found to be relatively low.

Recommendations

Introduction

The Kenyan price of sugar has been maintained at a level that is slightly higher than the level of the world market price for sugar. The Government sugar pricing policy has been designed such that it offers a price that is an incentive toward increased sugar production, while regulating consumption in order to facilitate an orderly transition toward a self-sufficiency status for the sugar industry. However, the sale of cheaper sugar imports at the domestic price has resulted in the generation of a sugar fund. This fund has been used to stabilize the domestic price in the face of the highly volatile world market price for sugar.

Projections and parametric analysis of production and consumption have indicated that the sugar industry may attain the self-sufficiency status by the end of the 1980s. However, one cannot be confident that the rate of growth in production that was experienced during the 1970s, and which is required if the self-sufficiency status is to be attained at the predicted period, can be sustained during the 1980s. In order that a pricing policy alone can be used to achieve the goal of self-sufficiency, pricing measures may have to be designed primarily to curb consumption rather than raise the rate of growth in production. Such measures have been described as socially undesirable. Hence, one cannot justify a recommendation that supports such pricing measures because they cannot be regarded as market improvement proposals.

Market Improvement Proposals

This study proposes some market improvement measures that are designed to regulate production rather than consumption. The proposed measures would leave the sugar market to operate as freely as possible, while supporting production in order to ensure a steady growth toward levels that are consistent with the policy goal of self-sufficiency. Theory suggests that subsidization of domestic production is superior to imposition of taxes on consumption as a commodity pricing policy. This statement is based on a paper in which Bhagwati and Ramaswami prove that subsidization of domestic production is superior to imposition of taxes on imports as a method for correcting distortions in the domestic market.[1] Any method designed to correct distortions in the domestic market for an open economy attempts to ensure that the usual economic optimum conditions (which are usually referred to as the marginal conditions) are satisfied or observed as closely as possible.

The theory of optimum subsidy in the face of domestic market distortions forms the foundation of the recommended policy measures in this study. If there are distortions in the domestic market, Bhagwati and Ramaswami show that a tariff policy can never correct such distortions and that the optimum strategy would be the pursuit of a policy of free trade.[1] This statement would apply in the case of seeking and defining an optimum market improvement strategy for Kenya.

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[1] J. Bhagwati and V.K. Ramaswami, "Domestic Distortions, Tariffs, and the Theory of Optimum Subsidy," Journal of Political Economy, Vol. LXXI, No. 1 (February, 1963), pp. 44-50. The distortions relate to lack of equality in the usual economic marginal conditions.

This study recommends two policy measures that are considered as a practical approximation of the corrective measures for distortions in the domestic market. The first recommended policy measure requires that the current domestic price of sugar be indexed to the movements in the average world market price for sugar. The second recommended policy measure requires the Government to subsidize domestic sugar production only during those periods when the proposed domestic sugar price that is indexed to the world market price does not adequately cover the domestic cost of sugar production.

The first policy recommendation implies that the domestic price of sugar should be allowed to change directly in proportion to changes in the world market price, thus eliminating the downward stickiness that has characterized the domestic price so far and also allowing the domestic market to operate as freely as possible while maintaining the current difference in the levels of the domestic and world market prices for sugar. This difference was shown to be about 20 percent of the domestic price so that some extra revenues will continue to be generated whenever some sugar is imported and sold at the indexed domestic price. This extra revenue should continue to build up the hitherto price stabilization fund, whose role should now change to that of a producer price-support fund. The proposed producer price-support fund should then be maintained in order that funds are available for subsidizing domestic sugar production when necessary, as proposed in the second policy recommendation.

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[1] _Ibid._

Concluding Remarks on Policy Recommendations

The sugar pricing policy that has been followed by the Government so far has been designed so as to facilitate an orderly production and consumption towards levels that are consistent with a self-sufficiency status. The policy recommendations that have been advanced in this study are expected to lead toward the same goal of self-sufficiency status without imposing undue restrictions on sugar consumption through a pricing policy. These recommendations are thus considered to be more socially equitable.

The proposed indexation of the current domestic price to the world market price does not disrupt either the generation of the hitherto price stabilization fund or the established production pattern. This pattern of production is to be enhanced through a subsidization program whenever the level of domestic price falls below the average production cost. The main objective of the policy proposals is to correct distortions in the domestic market by ensuring that the usual economic optimum conditions are observed as closely as possible. Since the level of sugar imports is low and is likely to continue to decline, the price-support fund generated from the sale of cheaper imported sugar at the indexed domestic price may not always have adequate resources for the subsidization of domestic production of sugar. Therefore, the Government may have to top-up the fund from other revenue sources from time to time.

Need for Further Research

A number of institutional arrangements were discussed in earlier chapters, but not much was examined in relation to the sugar industry in Kenya. Kenya is a signatory to the International Sugar Agreements (ISA), and further research work could be done to examine the role of Kenya in such Agreements and determine how such institutional arrangements may have influenced the domestic sugar policy and also assess their impact on the domestic patterns of production and consumption of sugar.

The sugar industry has been treated in this study primarily as if the industry were isolated from the rest of the economy. There is a possibility that too much of the country's resources are being used in the development of the sugar industry. An evaluation of the opportunity cost of sugar production, or the assessment of allocative efficiency in the sugar industry in general, is recommended as a useful step towards a study of the sugar industry in relation to the rest of the economy. A comparison of domestic and international production costs for sugar would also be a useful step in the proposed integrative study.

Finally, a number of changes have, or may have, taken place with regard to the situation of the sugar industry in Kenya since the initiation of this study in 1978. An important change in this regard is the establishment of two new sugar mills, one at Nzoia in the Western Province and the other at Awendo in the South Nyanza Province. The new mills were expected to become operational by the end of 1978. This situation would likely lead to increases in the level of domestic production of sugar and probably result in an earlier date for the achievement of a self-sufficiency status than the date predicted in the study. Hence, there is need to update the results of this study as more information on the sugar industry becomes available in the future.

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APPENDICES

Appendix A-1

Producer (Cane), Wholesale (Ex-Factory) and Retail (Consumer) Prices* of Sugar in Kenya, 1969-1976

[Kshs. per Metric Ton]

Year	Producer Price		Wholesale Price		Retail Price	
	Nominal	Real	Nominal	Real	Nominal	Real
1969	45	46	905	923	1550	1582
1970	45	45	905	905	1550	1550
1971	45	44	1004	984	1650	1618
1972	50	50	1040	1040	1850	1850
1973	52	48	1230	1139	1850	1713
1974	62	50	1860	1500	2400	1935
1975	89	61	3210	2184	3500	2381
1976	105	66	4205	2628	4500	2813

*As explained in the main body of the thesis, cane prices and ex-factory prices of sugar are taken as proxies for the sugar producer prices and the wholesale sugar prices respectively, in order to facilitate the analysis of sugar price spreads.

SOURCES: (1) Government of Kenya, Economic Survey (Nairobi: Government Printer, Various Issues up to 1976);
(2) Author's work (for Calculations of Real price values).

Appendix A-1-1

Producer, Wholesale and Retail Price Indices for Sugar in Kenya, 1969-1976

(1970 = 100)

Year	Producer Price		Wholesale Price		Retail Price	
	Nominal	Real	Nominal	Real	Nominal	Real
1969	100.00	102.04	100.00	101.99	100.00	102.04
1970	100.00	100.00	100.00	100.00	100.00	100.00
1971	100.00	98.04	110.93	108.73	106.45	104.36
1972	111.11	111.11	114.92	114.92	119.35	119.35
1973	115.56	107.00	135.91	125.86	119.35	110.51
1974	137.78	111.11	205.52	165.75	154.84	124.87
1975	197.78	134.54	354.70	241.33	225.81	153.61
1976	233.33	145.83	464.64	290.39	290.32	181.45

SOURCE: Author's Work (Calculations Based on Data in Appendix A-1).

Appendix A-1-2

Index of Quantities of Cane Processed Into Sugar in Kenya, 1962-1976 (1970 = 100)

Year	Cane Quantity Index	Year	Cane Quantity Index
1962	34.34	1970	100.00
1963	35.32	1971	94.96
1964	41.41	1972	73.20
1965	35.67	1973	106.47
1966	35.46	1974	118.46
1967	48.68	1975	119.58
1968	65.27	1976	141.50
1969	89.63		

SOURCE: Author's Work (Based on Data in Table 5-1).

Appendix A-1-2

Indices of Wholesale and Retail Price Spreads for Sugar in Kenya, 1969-1976 (1970 = 100)

Year	Wholesale Price Spread		Retail Price Spread	
	Nominal	Real	Nominal	Real
1969	100.00	102.02	100.00	102.04
1970	100.00	100.00	100.00	100.00
1971	100.16	98.14	111.51	109.33
1972	125.58	125.58	115.12	115.12
1973	96.12	88.99	136.98	126.83
1974	83.72	67.44	209.10	168.60
1975	44.96	30.54	362.91	246.88
1976	45.74	28.53	476.74	297.97

SOURCE: Author's Work (Calculations Based on Data in Appendix A-1).

Appendix A-2

Indices of Production, Consumption and Imports of Sugar and the Average Weather Index for the Cane-Producing Zones in Kenya, 1955-1976

(1970 = 100)

Year	Production	Consumption	Imports	Weather
1955	13.60	34.81	100.00	72.41
1956	16.00	41.14	118.42	72.72
1957	16.00	43.67	128.95	93.48
1958	22.40	44.94	113.16	67.79
1959	22.40	49.37	131.58	99.74
1960	26.40	55.70	152.63	105.48
1961	26.40	58.86	157.89	67.22
1962	26.40	63.29	176.32	59.25
1963	30.40	62.03	157.89	110.48
1964	28.00	66.46	184.21	99.72
1965	23.20	70.89	218.42	98.42
1966	28.80	76.58	223.68	105.42
1967	48.00	76.58	160.53	108.96
1968	64.80	83.54	134.21	130.29
1969	92.00	89.87	71.05	90.30
1970	100.00	100.00	100.00	100.00
1971	99.20	113.92	155.26	89.44
1972	73.60	123.42	300.00	119.18
1973	110.40	137.34	200.00	107.32
1974	130.40	142.41	210.53	81.84
1975	144.00	148.73	131.58	95.57
1976	152.00	156.96	131.58	99.73

SOURCE: Author's Work (Based on Data in Tables 5-1 through 5-5).

Appendix A-3

Retail Sugar Price, Maize Producer Price and Consumer Price Indices in Kenya and the World Market Sugar Price Index, 1955-1976 (1970 = 100)

Year	Kenya Nominal Prices		Kenya CPI		World Nominal Sugar Price
	Sugar	Maize	Foods Only	Composite	
1955	79.35	141.16	79	75	88.04
1956	83.87	141.16	81	78	94.32
1957	70.97	152.53	83	80	140.22
1958	82.58	140.48	81	81	95.09
1959	83.87	108.43	80	81	80.78
1960	83.87	128.51	81	81	84.40
1961	80.65	142.57	82	83	94.73
1962	87.74	142.57	85	86	84.26
1963	94.84	96.39	87	88	225.26
1964	94.84	108.43	90	91	155.54
1965	94.84	130.52	91	92	53.50
1966	99.35	130.52	97	96	47.74
1967	99.35	148.59	98	98	50.86
1968	99.35	115.66	99	98	51.67
1969	100.00	112.45	98	98	87.08
1970	100.00	100.00	100	100	100.00
1971	106.45	113.25	102	102	122.24
1972	119.35	137.35	100	100	197.55
1973	119.35	139.76	105	108	256.79
1974	154.84	149.80	124	124	806.00
1975	225.81	234.54	150	147	555.25
1976	290.32	261.04	160	160	312.61

SOURCE: Author's Work (Based on Data in Tables 5-1 through 5-5).

Appendix A-4

Indices of Population and Disposable Income in Kenya, 1955-1976 (1970 = 100)

Year	Population	Total Disposable Income		Per Capita Disposable Income	
		Nominal	Real	Nominal	Real
1955	57.17	32.29	43.05	56.49	75.32
1956	58.72	34.49	44.22	58.77	75.35
1957	60.31	36.72	45.90	60.89	76.11
1958	61.92	37.09	45.79	59.93	73.99
1959	63.59	38.34	47.33	60.29	74.43
1960	72.26	40.30	49.75	55.73	68.80
1961	74.37	40.12	48.34	53.96	65.01
1962	76.54	43.51	50.59	56.81	66.06
1963	78.78	46.18	52.48	58.61	66.60
1964	81.07	63.94	70.26	78.91	86.71
1965	83.39	63.27	68.77	75.83	82.42
1966	87.09	72.00	75.00	82.64	86.08
1967	90.12	75.70	77.24	84.00	85.71
1968	93.32	83.74	85.45	89.73	91.56
1969	96.88	91.03	92.89	93.95	95.87
1970	100.00	100.00	100.00	100.00	100.00
1971	103.92	113.57	111.34	109.29	107.15
1972	107.48	126.50	126.50	117.68	117.68
1973	111.13	141.37	130.90	127.21	117.79
1974	114.96	175.23	141.31	152.42	122.92
1975	119.32	201.05	136.77	168.48	114.61
1976	123.33	245.83	153.64	199.32	124.58

SOURCE: Author's Work (Based on Data in Tables 5.1 through 5-5).

Appendix A-5

A Review of the Major Scanning Techniques or Tests for the Presence of Econometric Problems in Regression Models and for the Detection of Structural Changes in Such Models

Introduction

The chapter on methods of analysis indicates that the models were estimated using least square estimation techniques. Least square estimates are BLU (i.e., best, linear, unbiased) if the random term u satisfies some general assumptions, namely that u has zero mean and constant variance. This proposition, together with the set of conditions under which it is true, is known as Gauss-Markov least-squares theorem.[1] Specifically, the Gauss-Markov theorem that states that the least square estimates are best (i.e., have the smallest variance) as compared with any other linear unbiased estimator obtained from any other econometric methods is the major reason for the popularity of the ordinary least squares (OLS) estimation method. The econometric problems alluded to in the analysis arise from the violation of one or more of the Gauss-Markov conditions (i.e., the conditions under which least square estimates are BLU).

Specific Econometric Problems and Tests for Their Presence

Heteroscedasticity

A necessary condition for linear estimators to have desirable properties is that the random term u has a constant variance, i.e.:

$$E(u_i^2) = \sigma^2$$

This condition is referred to as homoscedasticity. If the condition is violated, then heteroscedasticity is said to be present. Since the variance of u is no longer a constant, the estimates of the structural coefficients of the model would have very large variances and will likely be statistically insignificant.

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[1] A. Koutsoyiannis, Theory of Econometrics (London: The Macmillan Press Ltd., 1976), pp. 104-111. A detailed discussion of the theorem can be found in most textbooks in econometrics.

Tests for the presence of heteroscedasticity attempt to establish the lack of a constancy in the variance of the stochastic term u. Various tests are available, but the simplest ones to apply include the Spearman rank-correlation test and the Goldfeld and Quandt tests. The two tests are reviewed below.

1. The Spearman Rank-Correlation Test

This test may be applied to either small or large samples and may be outlined as follows:

1. Regress Y on X

$$Y = b_0 + b_1X_1 + u$$

and obtain the residuals, e's, which are estimates of the u's.

2. Order the e's (ignoring their sign) and the X values in ascending or descending order and compute the rank correlation coefficient $r'_{e.x}$ using the formula:

$$r'_{e.x} = 1 - \frac{6\Sigma D_i^2}{n(n^2 - 1)}$$

where D_i = difference between the ranks of corresponding pairs of X and e, and n = observations in the sample.

A high rank correlation coefficient suggests the presence of heteroscedasticity. The statistical significance of r is then determined by using the Spearman Rank-Correlation Coefficient Critical Value tables. If r' is significantly different from zero, then heteroscedasticity is present.

If the relationship has more explanatory variables, one may compute the rank correlation coefficient between e_i and each of the explanatory variables separately.

2. The Goldfeld and Quandt Test

(S.M. Goldfeld and R.E. Quandt, "Some Tests for Homoscedasticity," J. Am. Statist. Ass., Vol. 60, 1965, pp. 539-47.)

This test is applicable to large samples. The observations must be at least twice as many as the parameters to be estimated. The test assumes normality and serially independent u_i's. The hypothesis to be tested is the null hypothesis:

H_0 : u_i's are homoscedastic

and is tested against the alternative hypothesis:

H_1 : u_i's are heteroscedastic (with increasing variances).

The steps involved in the Goldfeld and Quandt test may be outlined as follows:

1. Order the observations according to the magnitude of the explanatory variable X.
2. Select arbitrarily a certain number (c) of central observations from the analysis. (It has been found from some experiments by Goldfeld and Quandt that for samples larger than n = 30, the optimum number of central observations to be omitted from the test is approximately a quarter of the total observations, for example 8 for n = 30, 16 for n = 60.) The remaining (n - c) observations are divided into two sub-samples of equal size ((n - c)/2), one including the small values of X and the other including the large values of X.
3. Fit separate regressions to each sub-sample, and obtain the sum of squared residuals from each of them:

Σe_1^2 = residuals from the sub-sample of low values of X, with $[(n - c)/2] - K$ degrees of freedom, where K is the total number of parameters in the model

Σe_2^2 = residuals from the sub-sample of high values of X, with the same degrees of freedom, $[(n - c)/2] - K$

If each of these sums is divided by the appropriate degrees of freedom, one obtains estimates of the variances of the u's in the two sub-samples. The ratio of the two variances

$$F^* = \frac{\Sigma e_2^2/[\{(n-c)/2\} - K]}{\Sigma e_1^2/[\{(n-c)/2\} - K]} = \frac{\Sigma e_2^2}{\Sigma e_1^2}$$

has an F distribution (with $v_1 = v_2 = [\{n-c\}/2] - K = [\{n-c-2K\}/2]$ degrees of freedom, where n = total number of observations, c = central observations omitted, K = number of parameters estimated from each regression).

If the two variances are the same (that is, if the u's are homoscedastic) the value of F* will tend to 1. If the variances differ, F* will have a large value (given that by the design of the test $\Sigma e_2^2 > \Sigma e_1^2$). The observed F* is compared with the theoretical value of F with $v_1 = v_2 = (n-c-2K)/2$ degrees of freedom (at a chosen level of significance).

The Theoretical (obtained from the F-Tables) value of F is the value that F would assume if the null hypothesis is true, that is, if the u's are homoscedastic. If $F^* > F$, accept that there is heteroscedasticity (that is, reject the null hypothesis of no difference between the variances of u's in the two sub-samples). If $F^* < F$, accept that the u's are homoscedastic (in other words, accept the null hypothesis). The higher the observed F^* ratio, the stronger the heteroscedasticity of the u's.

Autocorrelation

The terms autocorrelation, autoregression, and serial correlation are all synonymously used to imply the presence of serially correlated stochastic variable u in the model, so that the basic Gauss-Markov condition:[1]

$$E(u_i u_j) = 0 \quad \text{for } i \neq j$$

is violated. The outcome is the fact that estimated structural coefficients will not be BLU: the coefficients will generally have very high variances and likely be statistically insignificant.

Intuitively, some rough idea of the existence and the pattern of autocorrelation may be gained by plotting the regression residuals either against their own lagged value(s), or against time.

However, there are more accurate tests for the incidence of autocorrelation. The traditionally applied tests are the von Neumann ratio and the Durbin-Watson test. The Durbin-Watson d-statistic and h-statistic tests were used in this study and are the tests reviewed here.[2]

1. The Durbin-Watson d-statistic tests

(J. Durbin and G.S. Watson, "Testing for Serial Correlation in Least-Squares Regression," two articles in Biometrica 1950 and 1951).

The Durbin-Watson d-statistic test is applicable to small samples and is appropriate only for the first-order autoregression scheme ($u_t = \rho u_{t-1} + v_t$). The test involves the determination of the degree of serial correlation ρ (rho), followed by tests of statistical significance for this value of ρ. The estimate for ρ is obtained from:

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[1] Further discussions of the Gauss-Markov conditions can be found in H. Theil, Principles of Econometrics (New York: John Wiley and Sons, Inc., 1971), pp. 119-120.

[2] For a discussion of the von Neumann ratio, see A. Koutsoyiannis, op. cit., p.206.

$$\rho = \frac{\Sigma u_t u_{t-1}}{\Sigma u_t} \text{ or } \hat{\rho} = \frac{\Sigma e_t e_{t-1}}{\Sigma e_t}$$

where $0 \leq \rho \leq 1$, $\hat{\rho}$ is the estimate for ρ and u_t and u_{t-1} are the values of the residuals during current and previous time periods respectively (empirically, u_t is estimated by e_t as before). The statistical significance for ρ (at a specified level of significance) is obtained from the calculated d-statistic (i.e., d*). The test may be outlined as follows:

The null hypothesis

$$H_0 : \rho = 0$$

(the u's are not autocorrelated) is tested against the alternative hypothesis

$$H_1 : \rho \neq 0$$

(the u's are serially dependent).

To test the null hypothesis first compute the statistic

$$d^* = \frac{\sum_{t=2}^{n} (e_t - e_{t-1})^2}{\sum_{t=1}^{n} e_t^2}$$

where e's are the OLS estimates of u's.

The next step is to compare this empirical sample value of d* with the theoretical value of d, with n - K degrees of freedom (where K is the total number of the parameters). The theoretical d value is the value which d would assume if the null hypothesis were true, that is, if autocorrelation did not exist. The problem is that the exact distribution of d is not known. But Durbin and Watson have established that this distribution lies between two other distributions, d_L and d_U, where d_L denotes the lower-bound values of d and d_U denotes the upper values of d. Durbin and Watson have tabulated these lower and upper values with (n - K) degrees of freedom at the 5 percent and the 1 percent level of significance.[1]

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[1] The Durbin-Watson d-statistic and the von Neumann ratio are mathematically related (see A. Koutsoyiannis, op. cit., p. 207).

The empirical d* value, calculated from the regression residuals, is then compared with the d_L and d_U values of the Durbin-Watson tables (with n - K degrees of freedom) as follows:

A. Testing for positive autocorrelation: $\rho > 0$

(1) If $d^* \geq d_U$ (with n - K degrees of freedom) one accepts the null hypothesis $\rho = 0$, that is, one accepts that there is no autocorrelation.

(2) If $d^* \leq d_L$, one rejects the null hypothesis $\rho = 0$, that is, one accepts that there is positive autocorrelation in the function

(3) If $d_L < d^* < d_U$, the test is inconclusive, that is, one cannot be sure of the presence or absence of autocorrelation. What is required in this case is an increase of the observations (n).

B. Testing for negative autocorrelation: $\rho < 0$.

(1) If $(4 - d^*) \geq d_U$, there is no autocorrelation, that is, one accepts the null hypothesis $\rho = 0$.

(2) If $(4 - d^*) \leq d_U$, there is negative autocorrelation in the function; one rejects the null hypothesis $\rho = 0$.

(3) If $d_L < (4 - d^*) < d_U$, the test is inconclusive.

From the theory, one can show that the d-statistic value for large samples (asymptotically) is approximately equal to 2 because d and ρ are related through the expression:[1]

$$d \simeq 2(1 - \hat{\rho})$$

From the above expression for d, one can deduce that the value of d lies between 0 and 4 for the following reasons:

Firstly, if there is no autocorrelation $\hat{\rho} = 0$ and $d = 2$. Thus, if the empirical $d^* \simeq 2$, one accepts that there is no autocorrelation in the function.

Secondly, if $\hat{\rho} = +1$, $d = 0$ and one has perfect positive autocorrelation. Therefore, if $0 < d^* < 2$, there is some degree of positive autocorrelation, which is stronger the closer d* is to zero.

Thirdly, if $\hat{\rho} = -1$, $d = 4$ and one has perfect negative autocorrelation. Therefore if $2 < d^* < 4$, there is some degree of negative autocorrelation, which is stronger the higher the value of d*.

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[1] See A. Koutsoyiannis, op. cit., p. 208.

From the above considerations, values of d less than d_L are in the critical region for positive autocorrelation while values of d greater than $(4 - d_U)$ are in the critical region for negative autocorrelation. The Durbin-Watson test in the null hypothesis of zero autocorrelation (that is, for $\rho = 0$) is carried out indirectly by testing the equivalent hypothesis $d = 2$.

2. Other Approaches to the Durbin-Watson d-test and the h-statistic test.

The Durbin-Watson d-test has several shortcomings. Firstly, the d statistic is not an appropriate measure of autocorrelation if among the explanatory variables there are lagged values of the endogenous variable. Secondly, the range of values of d over which the Durbin-Watson test is inconclusive ($d_L < d^* < d_U$ when testing for positive autocorrelation) has been a drawback to its application. Various writers,[1] including Durbin[2] himself, have suggested alternative tests for serial correlation, which are more accurate and more powerful than the Durbin-Watson d-test. However, these tests are invariably more complicated and costly in computations. Furthermore, some of them are based on stronger assumptions. Given the shortcomings of the alternative tests, several econometricians have followed the practice of applying the Durbin-Watson d-test in the following amended form:

Reject the null hypothesis (H_0: $\rho = 0$) if $d^* < d_U$.

Accept the null hypothesis if $d^* > d_U$.

In the amended test, the rejection (critical) region includes not only the values of $d < d_L$ but also the values $d_L < d < d_U$, which are inconclusive in the original Durbin-Watson d-test. The above amendment of the original Durbin-Watson test is inaccurate, because the levels of significance of the original test are certainly affected by extending the rejection region

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[1] See H. Theil and A.L. Nagar, "Testing the Independence of Regression Disturbances," Journal of American Statistics Association, Vol. 56 (1961), pp. 793-806. See also R.C. Henshaw, Jr., "Testing Single-Equation Least-Squares Regression Models for Autocorrelated Disturbances," Econometrica, Vol. 34 (1966), pp. 646-60.

[2] J. Durbin, "An Alternative to the Bounds Test for Testing for Serial Correlation in Least-Squares Regression," Econometrica, Vol. 38 (1970), pp. 422-9.

over the range of the inconclusive d values. The amendment, however, may be justified on the grounds of the seriousness of autocorrelation in regression analysis.[1]
Thirdly, the Durbin-Watson test is inappropriate for testing for higher order serial correlation or for other forms of autocorrelation (e.g., for nonlinear forms of serial dependence of the values u_t).

An alternative test for autocorrelation in models having lagged endogenous variables in the set of explanatory variables is the h-statistic test. The h-test is considered more reliable than the d-test in the establishment of the presence of autocorrelation.[2]

The h-statistic can be calculated from the calculated d-statistic or ρ (rho) values by using the relationships:

$$\text{(i)} \quad \rho = 1 - d$$

$$\text{(ii)} \quad h = \rho \cdot \sqrt{\frac{n}{1 - nV(b_1)}}$$

where ρ(rho) or d may be calculated from the relationships given above, $V(b_1)$ is the estimate of the variance of the coefficient for the lagged dependent variable that appears in the model as an explanatory variable, and n is the sample size. The statistical significance of the calculated h-statistic is determined by using the critical h-statistic tables. For example, if $h > 1.645$, one would reject the null hypothesis $H_0{:}\rho=0$ at 5 percent level.

Multicollinearity

The presence of multicollinearity implies that virtually linear relationships exist between the independent variables in the model so that it becomes difficult to compute reliable estimators. The real problem here is that reliable estimates of individual regression coefficients become difficult to obtain, but multicollinearity does not affect the predictive power of the regression equation. Indeed, multicollinearity leaves the sum of the estimated coefficients unaffected.[1]

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[1] See J. Johnson, Econometric Methods (New York: McGraw-Hill Book Company, 1972), p. 258.

[2] Ibid., pp. 307-313.

There are three quick methods for establishing if some multicollinearity does exist in a multiple regression model. First, an examination of the correlations matrix provides a measure of the pairwise linear relationships between independent variables. This examination is a sufficient indicator for the presence of some multicollinearity. The second test involves the examination of t-statistics for the estimated regression coefficients. If there were strong theoretical expectations that a variable would be a statistically significant explanatory variable but the t-statistic test is negative, the observed statistical insignificance may be due to a linear relationship with some other variables in the model. The third test involves the examination of the value of R^2, the multiple coefficient of determination. If R^2 is statistically significant, but few or none of the estimated structural coefficients are statistically significant, then multicollinearity is likely to be predominant.

The three tests described above will likely detect a high degree of multicollinearity: they cannot offer evidence of negligible multicollinearity. A number of more rigorous methods of establishing the presence of even negligible multicollinearity are available, though no one method can be regarded as perfect. These methods (tests) for the detection of multicollinearity include a method based on Frisch's confluence analysis and the Farrar-Glauber test. The Farrar-Glauber test appears to be easier to manipulate in empirical studies and is the method reviewed in this study.[2]

The Farrar-Glauber method offers a comprehensive test for multicollinearity. The technique facilitates the identification of the impact of all other independent variables in the original estimating model on a chosen independent variable X_i. For instance, if the original estimating equation was:

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[1] D. Orr, Applied Econometrics (Toronto: Institute for Policy Analysis, University of Toronto, Canada, 1977), p. 56.

[2] For more details of the Farrar-Glauber technique, and for a discussion of Frisch's method of confluence analysis, see (i) A. Koutsoyiannis, op. cit., pp. 230-241; (ii) D. Orr, op. cit., pp. 54-61; and (iii) D.E. Farrar and R.R. Glauber, "Multicollinearity in Regression Analysis," Review of Economics and Statistics, Vol. 49 (1967), pp. 92-107.

$$Y = a_o + a_1X_1 + a_2X_2 + \ldots + a_nX_n + U$$

the Farrar-Glauber tests involve the estimation of the entire set of equations:

$$\left.\begin{array}{l} X_1 = b_o + b_1X_2 + b_2X_3 + \ldots + b_{n-1}X_n \\ X_2 = c_o + c_1X_1 + c_2X_3 + \ldots + c_{n-1}X_n \\ \vdots \\ X_n = z_o + z_1X_1 + z_2X_2 + \ldots + z_{n-1}X_{n-1} \end{array}\right\} \begin{array}{l}\text{Farrar-} \\ \text{Glauber} \\ \text{Equations}\end{array}$$

The R^2 and F-statistic values associated with each regression of Farrar-Glauber equation reflect the degree to which the relevant regressor independent variable is explained by the other independent variables. As $R^2 \rightarrow 1.0$ or $F \rightarrow +\infty$, the relevant independent variable becomes less and less useful as a relevant explanatory variable in the original estimating equation. The R^2 and F-statistic values for the Farrar-Glauber equations are an indicator for the degree of multicollinearity in the multiple regression estimating equation.

From the theory of the Farrar-Glauber technique, little will be lost in terms of the explanatory power of the original estimating model if any of the independent variables having a very high R^2 value in the Farrar-Glauber tests is dropped from the original estimating equation. If the F value for the Farrar-Glauber equation is not significant, the relevant regressor independent variable is not the source of severe multicollinearity in the original estimating equation, and this variable should be left in the estimating equation. If R^2 for the Farrar-Glauber equation is close to or greater than R^2 for the original estimating equation, the regressor in the Farrar-Glauber equation can be considered as a source of severe multicollinearity.[1] Such a variable should be omitted from the estimating model, or a method of estimating in the presence of this variable should be devised.

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[1] D. Orr, op. cit., p. 58.

Testing for Structural Changes in a Regression Model

There is a possibility that time series data for long periods of time may belong to statistically different populations, so that an estimated structural relationship for the entire period would be misleading. The correct approach would be to group data belonging to the same population together, so that regression equations for each set of data can be estimated. This approach would be appropriate even for cross-section data taken at different time periods.

The primary test for establishing whether the same population, or structural relationship applies to different data sets is the Chow test. Suppose there were two sets of data: (i) estimate the regression equation for the first set of data and record SSR_1, the sum of squared residuals for this regression equation; (ii) do the same for the second set of data and record SSR_2, the sum of squared residuals for the regression equation of the second set of data; (iii) estimate the regression equation for the pooled data (i.e., when the first and second sets of data are taken as belonging to the same population) and record SSR_T, the sum of squared residuals for the equation based on all observations. If the first and second sets of data belong to the same population, then $SSR_1 + SSR_2$ should not be significantly greater than SSR_T.[1]

The equality of the sum $SSR_1 + SSR_2$ with SSR_T is tested for by using an F-statistic test, where F is given by:

$$F = \frac{[SSR_T - (SSR_1 + SSR_2)] / (K + 1)}{(SSR_1 + SSR_2) / [n-2(K + 1)]}$$

where K = number of independent variables

n = total number of observations

and $F = F_{(K,\ n - K - 2)}$

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[1] D. Orr, op. cit., p. 160; M. Dutta, Econometric Methods (Cincinnati: South-Western Publishing Co., 1975), pp. 173-177.

Under certain specifications, dummy variables could be used to give the same test results as the Chow test.[1] This implies that dummy variables can be used to test for structural changes in econometric models. However, the dummy variable technique facilitates the testing of whether individual structural coefficients have changed while the Chow test is an overall test of the joint hypothesis that all coefficients have not changed significantly between the two periods under investigation. The common dummy variable method is to use the [0,1] dummy for the first and second periods respectively: (i) if D = [0,1] is used as an independent variable, then the dummy variable tests for a shift in the intercept term; (ii) if D = [0,1] is used interactively with a given independent variable, then the dummy variable tests for a change in the relevant slope coefficient. Hence, the inclusion of an intercept and all slope dummies will yield the same test results as would be obtained from the Chow test.

A Final Note on Appendix A-5

The above review of the basic scanning techniques or tests for the presence of econometric problems in regression models and for the detection of structural changes in such models is not exhaustive. More details could be obtained from econometric textbooks such as J. Johnson, Econometric Methods (New York: McGraw-Hill Book Company, 1972); M. Dutta, Econometric Methods (Cincinnati, Ohio: South-Western Publishing Co., 1975); D. Orr, Applied Econometrics (Toronto: Institute for Policy Analysis, University of Toronto, Canada, 1977); H. Theil, Principles of Econometrics (New York: John Wiley and Sons, Inc., 1971); and A. Koutsoyiannis, Theory of Econometrics (London: The Macmillan Press Ltd., 1976).

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[1] Ibid.